New York State Education Department

NEW YORK STATE MUSEUM

65th ANNUAL REPORT

1911

In 4 volumes

VOLUME 1

REPORT OF THE DIRECTOR 1911

AND

APPENDIX 1

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NATIONAL MUSEUM

TRANSMITTED TO THE LEGISLATURE MARCH 18, 1913

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UNIVERSITY OF THE STATE OF NEW YORK
1913

STATE OF NEW YORK

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STATE OF NEW YORK

No. 34

IN ASSEMBLY

MARCH 18, 1913

65th ANNUAL REPORT

OF THE

NEW YORK STATE MUSEUM

VOLUME 1

To the Legislature of the State of New York

We have the honor to submit herewith, pursuant to law, as the 65th Annual Report of the New York State Museum, the report of the Director, including the reports of the State Geologist and State Paleontologist, and the reports of the State Entomologist and the State Botanist, with appendixes.

ST CLAIR MCKELWAY
Vice Chancellor of the University

ANDREW S. DRAPER
Commissioner of Education

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Education Department Bulletin

Published fortnightly by the University of the State of New York

Entered as second-class matter June 24, 1908, at the Post Office at Albany, N. Y., under the act of July 16, 1894

No. 516 ALBANY, N. Y. APRIL 1, 1912

New York State Museum

JOHN M. CLARKE, Director

Museum Bulletin 158

EIGHTH REPORT OF THE DIRECTOR OF THE SCIENCE DIVISION

INCLUDING THE

65th REPORT OF THE STATE MUSEUM, THE 31st REPORT OF THE STATE GEOLOGIST, AND THE REPORT OF THE STATE PALEONTOLOGIST FOR 1911

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New York State Education Department
Science Division, February 23, 1912

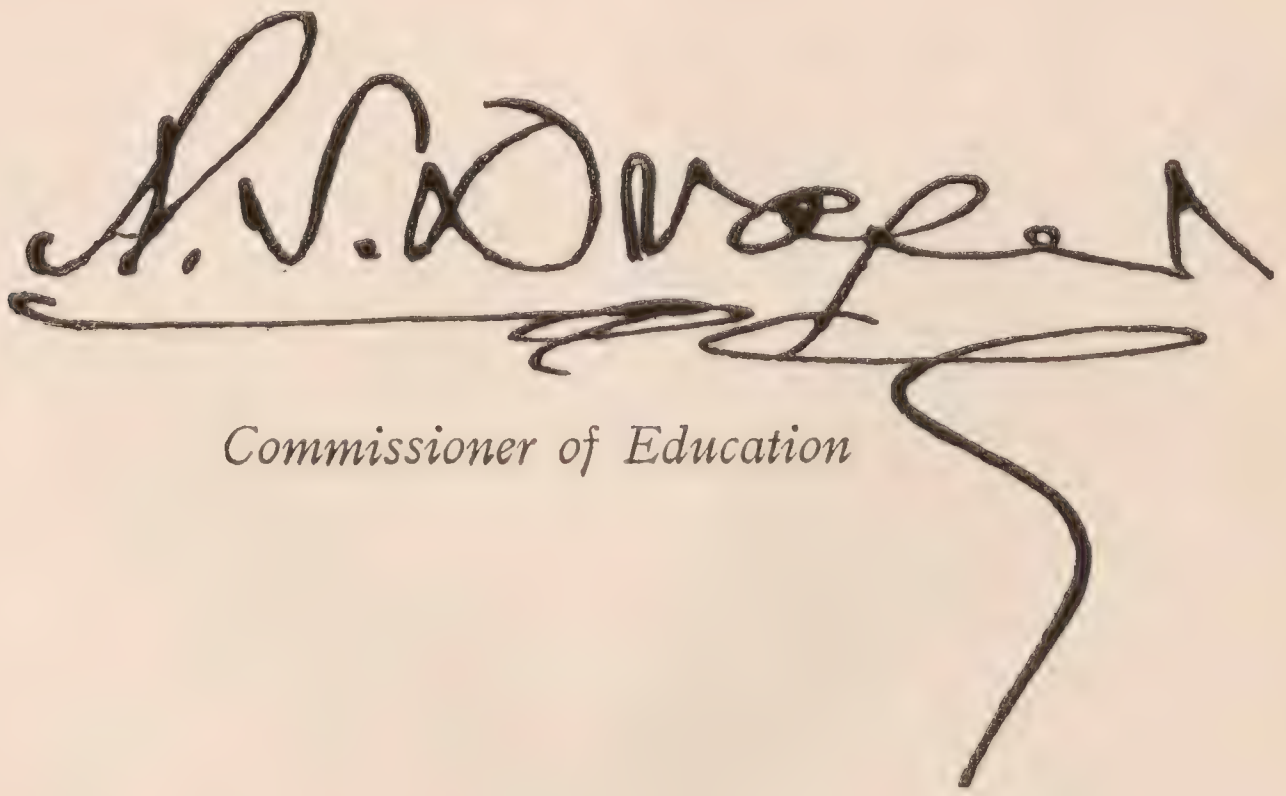
Hon. Andrew S. Draper LL.D.
Commissioner of Education

SIR: I have the honor to transmit herewith for publication as a bulletin of the State Museum, the annual report of the Director of the Science Division for the fiscal year ending September 30, 1911.

Very respectfully
JOHN M. CLARKE
Director

STATE OF NEW YORK
EDUCATION DEPARTMENT
COMMISSIONER'S ROOM

Approved for publication this 24th day of February 1912



Commissioner of Education

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John M. Clarke, Director

Museum Bulletin 158

EIGHTH REPORT OF THE DIRECTOR OF THE SCIENCE DIVISION

INCLUDING THE

65th REPORT OF THE STATE MUSEUM, THE 31st REPORT OF THE STATE GEOLOGIST, AND THE REPORT OF THE STATE PALEONTOLOGIST FOR 1911

INTRODUCTION

This report covers all divisions of the scientific work under the charge of the Education Department and concerns the progress made therein during the fiscal year 1910–11. It constitutes the 65th annual report of the State Museum and is introductory to all the scientific memoirs, bulletins and other publications issued from this office during the year mentioned.

Under the action of the Regents of the University (April 26, 1904) the work of the Science Division is "under the immediate supervision of the Commissioner of Education," and the advisory committee of the Board of Regents of the University having the affairs of this division in charge are the Honorables: T. Guilford Smith LL.D., Buffalo; Daniel Beach LL.D., Watkins; Lucian L. Shedden LL.D., Plattsburg.

The subjects to be presented in this report are considered under the following chapters:

I Condition of the Scientific Collections
II Report on the Geological Survey
III Report of the State Botanist

IV Report of the State Entomologist
V Report on the Zoology section
VI Report on the Archeology section
VII Publications of the year
VIII Staff of the Science Division and State Museum
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I

CONDITION OF THE SCIENTIFIC COLLECTIONS

During the year past the preparations for moving the collections into the Education Building have taken precedence over most other activities of the staff of the Museum. The collection rooms in Geological Hall have been closed to the public and at the present time the scientific materials are for the most part ready for removal. It became necessary early in the year to transfer all the stored material and publications of the Museum from the McCredie malthouse which has been in use many years as a storehouse, to their present quarters, the old Taylor brewery, in a distant part of the city, and to the latter place additions to the collections are at present being removed as they come in. In the installation of the collections in the Education Building all this material will come into requisition. There still remains in other buildings very much valuable material as indicated in my previous reports (see report for 1909–10).

The fire of March 29, 1911, which destroyed the west end of the Capitol and the State Library, involved the State Museum in very serious loss. On the landing at the head of the western stairway and along the corridors leading thereto the archeological collections were arranged. These were the historic Indian collections of costumes and implements which had been brought together during the existence of the institution. They contained materials gathered by Schoolcraft, Lewis H. Morgan and others in the early days when the Regents of the University gave special encouragement to the study of aboriginal life and records; and many later collections obtained by purchase or gift. As a whole the exhibit there arranged was the most complete assemblage of Iroquois materials in existence and because of its great scientific value, it had been removed from Geological Hall to the Capitol for greater safety. It is difficult to estimate the money value in this loss. I have placed it somewhat conventionally at $20,000 which is an approximation to the expenditure that would be necessary to replace the collections,

so far as replacement is possible. Numerically the loss is about 10,000 articles, of which not one-twentieth part, even of the stone implements, was saved. Such statements however take no account of the intrinsic value of the collection to students of ethnology, for these collections were widely known for their excellence and completeness.

The hope of replacing this loss in the quality of the materials destroyed can not be entertained, but there is still a reasonable expectation of making good some part of it by the acquisition of collections now in private hands among the citizens of New York. It is probably true that the last great collections of such culture relics have now been made. To replenish the lost collections from actual excavations is a rather remote chance. What is to be done to repair these collections should be done promptly before the private collections become dispersed as parts of estates.

The director does not mean to convey the impression that all the Indian collections of the Museum were thus destroyed. A goodly part of the more recent acquisitions were in another building at the time of the fire. All the wampum belts of the Iroquois which were received from the Six Nations some ten years ago and some specially notable articles besides were in safety deposit. The life casts and all the appurtenances of the Six Nations groups which are under construction were in other buildings.

The Museum was in a way fortunate in not losing all its scientific collections exposed in the Capitol. In the senate gallery corridor leading to the western stairway were a number of special exhibits, some of recently excavated Indian relics, others of fossil sponges, mineral crystals and pottery. The flames swept by the open end of this corridor taking everything in their path but nothing in the corridor itself was harmed. These cases still remain where they stood before the fire.

On account of the accumulation of the reserve stock of Museum publications it seemed wise at the time of the removal of this stock from one storehouse to another, to undertake a general distribution of the items of which the reserve was needlessly large. This reduction of stock was accomplished without impairing the necessary reserve for future demands and several thousand copies of these publications were thus distributed, for the most part to European libraries.

Valuable accessions to all departments of the Museum have been made during the year. Their character is given under chapter IX of this report.

II

REPORT ON THE GEOLOGICAL SURVEY

SOME PRACTICAL FEATURES OF NEW YORK GEOLOGY[1]

The services which geology may render to industry and technology are becoming widely recognized with the progress of organized survey work, but nowhere in the country perhaps is the relationship more historic or continuous with respect to actual records than in this State. The reports of the First Survey of New York, issued between the years 1837 and 1841, give prominence to the consideration of natural resources; their treatment of the mineral deposits particularly attains a measure of accuracy and comprehensive value that is at least surprising in view of the conditions under which they were prepared. So far as our knowledge goes they represent the earliest attempt to cover the physical features of a whole commonwealth with similar detail and to maintain a practical balance between the twofold objects, pure and applied knowledge, that should be subserved by such investigations.

Since their publication applied geology has gained materially by accumulated experience and improved methods of research. In keeping with the needs of modern industrial activities there has come a demand also for more specialized information than was afforded by the early reports, as well as for the extension of survey work into entirely new fields.

To illustrate more particularly the features of this development we outline briefly some of the later investigations carried out in New York with their purposes and results, making reference at the same time to other possible inquiries that may be followed with profit.

Mining. The relation of geology to mining is of first importance to the State, though New York it would appear is not generally considered to be very largely endowed with mineral resources. This view is justified only with regard to metallic minerals, of which, aside from iron ores, the deposits are neither varied nor specially extensive. But a production valued altogether at nearly $40,000,000 a year on the basis of crude materials is not an inconsiderable item, even when compared with the totals of many so-called mining states. As a matter of fact New York ranks well up in the list and ahead of nearly all states that are similarly lacking in wealth of mineral fuels.

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[1] By D. H. Newland.

Some of the most valuable mineral deposits are found within the series of sedimentary or stratified rocks which cover all the area outside of the Adirondacks and the Highlands region. Such deposits generally occur at definite horizons and it has been the task of the geologist to identify their position in the series of rock formations by study of the accompanying evidences supplied by fossils or by physical features. For example, the *rock salt* deposits of the western counties — and they furnish about one-third of the total salt produced in the entire country — are restricted to a certain position in the Salina shale formation. The geographical limits of this formation have been traced with accuracy so that there is no longer any doubt as to the region that may be profitably explored for that mineral.

In the same way it has been well established that the *gypsum* beds, which have given rise to a very important mining and manufacturing industry, form a special member of the sedimentary sequence having a well-recognized position and a real distribution. With the information at hand the prospector or intending investor may be accurately guided in his search for gypsum properties.

The supplies of *building stones, lime* and *cement* materials, and *clays* for the most part are governed by similar relations of occurrence. The clay deposits have been given thorough investigation from the various standpoints of distribution, chemical and physical characters, and technology of manufacture. Another special report deals with the lime and cement materials, and it is proposed to present the facts regarding our building stone supplies with like detail with a view to assisting their development.

The features surrounding the accumulation of *oil* and *natural gas* are admittedly obscure, though of late years considerable progress has been made toward the establishment of a practical basis for the exploration of these resources. The fact that both oil and gas are more often found in certain kinds of rocks than others is confirmed by experience. It is further recognized that the pools in each field usually occupy a definite position in the stratigraphic column, while their areal distribution may be influenced by the tectonic structures assumed by the strata, by underground water conditions or by other factors that come within the range of geological observation. The studies in the oil and gas territory of New York have been mainly concerned with the determination of the productive horizons for the several districts, in which work some very useful results have been obtained. An inquiry into the specific relations that characterize the

different occurrences, after the plan so successfully followed recently in the larger fields, might yield additional information valuable to these industries.

The *iron ores* of New York constitute one of its large mineral treasures. There are few areas of equal size in which so varied and widely distributed deposits are found. This variety of character is closely related to the geological features that surround their formation, and the interpretation of these features has a more or less direct bearing upon the issue of mining operations. One type of occurrence is represented by the Clinton hematite deposits which occupy a belt stretching across the central and western counties and which are clearly defined as to position by their stratified development. They have recently been explored and mapped. The very important magnetic ores of the Adirondacks, on the other hand, present a wide complexity of form and surroundings, as might be expected from their association with some of the most ancient rocks that are anywhere exposed. Still the study of their features has not been without result, as it has supplied the criteria for arranging them into two or three larger groups, each with a circumscribed geological range.

There remain for future investigation the Highlands magnetite district, the limonites of Columbia and Dutchess counties and the hematite ores of St Lawrence county, all of which have commercial importance.

The minor minerals lend a variety to the productive industry in the State, to which they also contribute very materially in the aggregate. The Adirondack region is the source of most of them. They include *talc, garnet* and *graphite* in extensive deposits that possess peculiar economic value to the trade, as well as *feldspar, quartz, pyrite, lead* and *zinc* which have a more limited representation. The production of zinc ore, it may be noted, has reached commercial proportions only within the last year. The areal mapping now in progress throughout the Adirondacks will help to explain the occurrence of these deposits, but many will repay detailed investigation of their distribution and field of usefulness.

With the gains of knowledge on these subjects has come not only a better appreciation of the positive elements in the State's mineral endowment, but also of the *limitations* that are naturally put upon this wealth and that should be respected by well-intentioned enterprise. The service to be rendered by directing industry into its legitimate channels may be not the least important function of the

geological survey. Time, money and energy have been wasted in pursuit of ventures which by a little inquiry would have been found absolutely futile at the start.

No doubt the fact that the New York series of rock formations does not contain workable coal beds has secured wide currency among the people of the State and its scientific demonstration by the First Survey has been of incalculable benefit in forestalling much fruitless search for coal deposits. There seems, however, to be a need for urging it upon public attention from time to time, as shown by the recent revival of interest in the matter. The regions from which reputed discoveries are most often reported include the Hudson river section, the Catskills and the southern tier of counties along the Pennsylvania border. In none are found rock formations equivalent in age to the proximate coal seams of the Appalachian field, the nearest approach to those being represented by the small areas of carbonic conglomerate in the southwestern corner of the State that are the last outlying remnants of the great conglomerate at the base of the productive measures. There can be no excuse for further waste of effort in mining for coal anywhere within the boundaries of the State.

It is recognized that the limits of the oil and gas fields are not accurately defined as yet, and there are still possibilities for discovering new sources of supply, especially of gas. Exploration may be guided in some measure by the results of geological work, as has been already stated. With the information which is available in regard to the productive formations and their distribution, the more promising territory may be broadly marked out; other considerations, also, show that only a part of the remaining area is at all likely to contain economically valuable pools of either oil or gas. The areas comprised within the Adirondacks and the Highlands are absolutely barren, as they are composed of crystalline rocks. The bordering region of thin or disturbed sediments affords very little chance of productive wells and this is equally true of the great mass of shales and sandstones that constitutes the "Hudson River formation" between the Adirondacks and the Highlands. The territory immediately west of these areas and extending as far as the meridian running through the middle of Oneida lake is of doubtful value, as demonstrated by experience with test wells. The actual productive area is restricted to the central and western parts, including about fifteen counties in all, of which only those near the western border have been found thus far to contain very large pools. In regard to

oil it may be said that the fields are small and it seems improbable that the industry will ever be extended outside of the three counties, Cattaraugus, Allegany and Steuben, where it has hitherto been confined.

Another matter that has been repeatedly discussed in connection with previous geological reports and the need of caution emphasized is the recurrent interest shown in the search for precious metals. The favored ground for prospectors is the Adirondack region where immense accumulations of sand and gravel have resulted from glacial wear upon the local rock formations. The same materials are scattered pretty much over all the section south of that region. There are no mineralized quartz veins to account for the existence of gold in the sands and wherever tested by the usual processes employed by commercial laboratories nothing more than a trace of gold and silver has been discovered. The subject has been treated so often and at such length as to require only passing mention here.

As of basic importance to the mining industry may be mentioned the *geological map,* especially the one now in preparation on the large scale of one mile to the inch. With this base there is attained a degree of refinement in denoting the rock formations and their bounds that should correspond to very general needs. Besides the immediate information it affords in regard to the various classes of quarry materials and stratified deposits available within the region mapped, it serves as a ground plan for directing all kinds of exploration, such as for oil, gas, water and the metallic ores. Its uses extend also to agriculture, engineering, and many everyday occupations.

Engineering. The application of geological methods and facts to various lines of engineering not connected with mining is hardly a new development, though it undoubtedly has assumed a broader aspect in the last few years than before. As an outcome of the public demand for service in the combined fields the profession of geological engineer has now a recognized standing, with a considerable body of practitioners.

In the location and examination of materials used in *engineering construction* the geological survey may render material assistance. This work naturally goes in hand with the field study and investigation of building stones, though requiring somewhat special treatment from the different standpoints with respect to physical quality and availability of the materials. The testing of stone for *road-making* and *concrete* is, of course, a function of engineering laboratories, yet very useful data in the way of preliminary classification may be had from geological methods, specially when aided by a knowledge

of modern petrography. The quality of sands and gravels for general construction purposes may be approximated in a similar manner.

The importance which the present scheme of highway improvement in the State has assumed requires that every possible advantage be taken of the situation with regard to the occurrence and availability of road-making materials. It is not necessary at this time to set forth in detail the geological considerations which enter into the subject. One element among many to be considered is the practical absence of suitable rock materials over the large area occupied by the Devonic shales and thin-bedded sandstones in the southern tier of counties, and the possible application of other local materials for use on the highways of that section. It would appear desirable to have a systematic inventory of the resources that may be drawn upon for road construction.

Another practical side of geological investigation is illustrated in the engineering of large projects which involve unusual care or discrimination in dealing with rock materials. In such cases the correct interpretation of structural features and processes of rock change that are in progress is often of considerable moment, if not on occasion of critical importance. The *foundation work* of large structures like dams and bridges that must be secured against the very slight but cumulative effects of physical agencies, and the excavation of canals and tunnels are examples of this kind.

A notable instance of the varied bearings which geology may have upon engineering is afforded by the construction of the Catskill aqueduct for the supply of water to New York City. The difficulty of the undertaking can scarcely be appreciated without a knowledge of the physical characteristics of the country in which the work had to be accomplished and the complications arising from the magnitude of the project. The engineering plans have been formed only after most extensive exploration of the features related to the surface and rock topography, character of the formations, tectonic structures, underground water circulations, and other matters which from the nature of the problem might influence the course or success of the work. To assemble and interpret the data a staff of geologists was maintained and was in constant touch with the situation. An insight into the manifold character of the scientific investigations and their relation to the conduct of the operations are given in a recent volume [1] prepared by a member of the geological staff. To

[1] Geology of the New York Aqueduct, by Charles P. Berkey. N. Y. State Museum Bulletin 146, 1911.

afford a general outline of the information collected and its bearing upon the work, the following paragraphs are quoted from that volume:

> The benefits of the studies have been twofold and reciprocal. On the one side the practical planning of the enterprise has constantly required an interpretation of geologic conditions as a guide to locations and methods and on the other the extensive investigations carried on have given an opportunity for practical application of geologic principles under conditions seldom offered and the data secured in additional explorations serve to make the detail of some of these complex features now among the most fully known of their kind. Examples of such cases are (a) the series of buried preglacial gorges (as in the Esopus, and Rondout and Wallkill and Moodna valleys) and (b) the completed geologic cross sections (such as the Rondout valley, the Peekskill valley, Bryn Mawr, etc.) and (c) the numerous additions to the knowledge of local rock conditions (such as that at Foundry brook, Rondout creek, Coxing kill, Pagenstechers gorge, Sprout brook, and others).
>
> Almost every locality has its own specific problem and its own peculiar differences of treatment and interpretation of features. Nearly all of the studies here presented came to the attention of the writer and others in the form of definite problems or questions involving an interpretation of geologic factors and an application to some engineering requirement. Some of these questions . . . are the location of buried channels beneath the drift, the character and depth of the drift, the kind of bedrock, the condition of bedrock for construction and permanence of tunnel, the underground water circulation, the occurrence of folds and faults, the position of weak zones, the depth required for substantial conditions, and many other similar problems.
>
> The cooperation of the geologist has likewise been sought in solving the difficulties at Panama, though unfortunately it appears this was not secured until the plans were formulated and the work of construction well under way. Many problems encountered in the work were of the kind that required the experience and information of the trained specialist. Some of the more important ones were related to the locations for the locks and dams, for which the element of security was critical, and to the availability of the local resources in building materials. It seems probable that if the results of the survey had been available at the start they would have had even greater value in guiding the course of operations.
>
> In combining the work of the geologist and engineer, Germany seems to be in advance of other countries. Public improvements like canals, railroads, and the regulation of streams are undertaken only after investigations of the geological factors that influence the

plans. In one year alone the geological survey of Prussia was called upon to supply information concerning ten projects relating to canals and streams.

There are few questions more often referred to the geologist than those concerning *water supply from underground sources.* With the crowding of our population many of the streams formerly serving households or communities have been rendered unfit for potable purposes except when subjected to expensive treatment, and consequently deep wells are being put down in numbers. The guidance to be had from detailed maps when these are available, or from records of previous borings into the same formations, should be of very considerable service, specially if supplemented by careful field observations. The general factors governing subterranean water supply, the real relations of the ground waters to the deep waters, and the courses of subterranean drainage, are still little known and here lies a field of much practical importance awaiting future development into accurate knowledge.

A related field of study is afforded by the *mineral springs* which are an important element in the natural wealth of the State. The need for conserving these valuable waters can scarcely be questioned since it is well known that they are liable to deterioration and exhaustion in much the same way as other natural resources; moreover in some places they are the basis of extensive enterprise and lend support to large communities. Governmental ownership or control of mineral springs is a policy that has long been pursued by European states, and recently a step in that direction has been taken with regard to those at Saratoga. The investigation of the waters, in particular the probable conditions of their derivation, storage and areal occurrence, is of pertinent interest to the matter of their conservation. To carry out such investigation is but to follow the precedents established by other countries.

AREAL GEOLOGY

In my last report I gave a list of all quadrangles on the topographic scale of 1 mile to 1 inch which have been issued in the form of detailed and completed geological maps. To this list were added those upon which reports have been rendered, though these are still unpublished, and those on which progress had been made by way of preliminary operations. During the year just closed reports with maps have been issued covering in detail the geology of the Alexandria Bay, Cape Vincent, Clayton and Grindstone quadrangles, all

of these pertaining to the St Lawrence region being brought together into one bulletin and under one title, "Geology of the Thousand Islands Region." The map and report on the Poughkeepsie quadrangle have also been issued. There has also appeared a special report which has proved of much interest to engineers as well as to geologists and the general public, as it deals with the earth structures revealed in the operations of the New York City Board of Water Supply. This report is entitled, "Geologic Features and Problems of the New York City (Catskill) Aqueduct."

In regard to actual work in the field, the progress made may be summarized under these regional headings:

Central and western New York. The areal work in this part of the State has progressed with reasonable celerity. The maps of the following quadrangles have been completed during the year: Dunkirk, Cherry Creek, Eden, Silver Creek, and Westfield, all in the Lake Erie region. Preliminary work has been carried into the Bath quadrangle, and field work has been completed on the Brockport, Hamlin, Albion and Oak Orchard quadrangles.

For this entire western New York region the present condition of the areal survey for the geologic map may be thus summarized.

Quadrangles published:

Auburn	Honeoye	Penn Yan
Buffalo	Naples	Portage
Canandaigua	Nunda	Tully
Elmira	Olean	Watkins
Genoa	Ontario Beach	Wayland
Hammondsport	Ovid	

Quadrangles reported:

Attica	Eden
Batavia	Phelps
Caledonia	Silver Creek
Depew	

Quadrangles mapped:

Albion	Hamlin
Brockport	Oak Orchard
Cherry Creek	Westfield
Dunkirk	

Quadrangles begun:

Bath	Medina

Eastern New York. Last year I recorded the progress made in the study of the region involving the Saratoga and Schuylerville quadrangles. The report on this area is not yet in readiness for issue but so far as present problems go, it is practically completed.

There is an element of special importance given to the study of this region by the presence of the Saratoga springs, the public concern in them since the State has undertaken to acquire and conserve them, and by the long outstanding problem as to the origin or cause of these saline carbonated waters.

Problems of subterranean geology are still obscure and difficult in the present state of the science but in seeking all available light on this, I have asked Prof. James F. Kemp to take over the special investigation of the nature of the Saratoga waters, in the belief that there was much to learn in regard to the origin of the springs which would in some measure serve the public at the present time. This report has been rendered and will presently be published. A summation of its broader results is here communicated.

Saline springs of Saratoga and vicinity. The report discusses the various springs which have been recorded in the region from Albany to Whitehall and is accompanied by a map giving their several locations. It appears that over eighty years ago saline carbonated waters were tapped for a short time by a deep well in Albany. None are known to the north until reaching Round Lake, where nearly as long ago a deep well found a short-lived supply. There is thus an interval of twenty-six miles from Albany to Round Lake in which no mineral waters of this character have been reported. Ballston and Saratoga Springs are next in northerly direction. In these two villages and in the five miles between them the great majority of the springs are situated and here the central area of their activity seems to be placed. The Gurn spring, eight miles north of Saratoga Springs, is the last of the strongly active, carbonated, saline varieties. There are records, however, of feebly active ones at the Quaker springs, eight miles east of Saratoga Springs; of one mildly active seventy or eighty years ago in the valley of the Moses kill, near South Argyle, on the east side of the Hudson river, and of one feebly carbonated, with high calcium content, at Whitehall, thirty-nine miles north of Saratoga Springs. All these remoter springs are weak in both carbonic acid and common salt as compared with those at Saratoga and Ballston. The several springs should be considered in groups along the lines of the great northeast and southwest faults, rather than as forming one belt.

There is next given a statement of the local geology upon the basis of the section established by Cushing and Ruedemann. The fault which traverses the village is discussed in some detail. The

general principles of ground waters follow, in which statement these kinds are established: those from the rainfall, usually described as meteoric; those from cooling and crystallizing bodies of igneous rock, usually called magmatic or juvenile; and those absorbed portions of ancient marine or fresh waters in which sediments are originally deposited and which are carried down with the sediments — connate waters. All three of these waters have been mentioned in the discussions of the springs, although not always under these particular names or in just this definite classification. The general principles which must be fundamental in the study are thus established.

The composition and character of the Saratoga and Ballston waters are next reviewed with care. As a necessary preliminary the methods of recording analyses are summarized and explained. The older ones are generally stated in grains in the U. S. gallon; the later ones in parts per million. The substances reported in the earlier and in many later ones are the estimated salts. The later practice is to use ions, or incompleted molecules, often elements, according to the modern conceptions of solutions. The discussion of the composition is carried out so as to employ all three of these methods of statement and to make the matter clear to any reader having the necessary familiarity with the subject. All the available analyses have been compiled and studied. They easily divide into three main groups in chronological order. One set was made by the early chemists, especially by Dr John H. Steel, and are, except one or two, earlier than 1840. Chemical analysis was then imperfectly developed and fewer ingredients were recorded than in the later ones.

A second set was made by Dr Charles F. Chandler in the 60's and early 70's. This set is quite complete and is of great value. A third set was made in the last ten years, almost all about seven years ago, by the Bureau of Chemistry of the United States Department of Agriculture, acting under the pure food legislation. The most recent set is that made by the State Board of Health for the commission having the springs in charge.

The older sets have been plotted in series of curves, both as salts and as ions, so as to show at a glance the ranges in kind and amount of dissolved substances. In the accompanying discussion the maxima, minima, and ranges are emphasized. Such analyses as are based on artificially strengthened samples are more or less recognizable.

Having reviewed the composition as regards dissolved salts, attention is given to the carbonic acid gas. Its properties of solution in water, especially as affected by pressure and temperature, are stated and its maximum, minimum and general amounts in the spring waters are reviewed. The phenomena of the "water seal" is next explained.

The temperatures of the waters are given, as are also the specific gravities.

The classification of mineral waters in general and of the Saratoga waters in particular receive attention. They all come under the alkaline-saline and saline classes, chiefly the former. All are muriated and sodic. Practically all are carbon-dioxated. Some are lithic, bromic or iodic, one or several.

The variations in the waters from a comparison of the analyses over intervals of time are discussed. In the springs of Saratoga there is an increased strength from the early analyses of 1840 to those of 1870, probably from better casing off of the surface waters. From 1870 to 1903 there is a marked falling off in strength. In Ballston we have not such complete analytical records, but some famous old springs have dropped out of sight and of one deep-drilled well, put down in 1867, we have two good analyses, 1869 and about 1905. There is no appreciable change in composition.

The report concludes with a discussion of the origin or source of the waters, gas and salts. All the views previously expressed are first passed in review. They are practically of two kinds:

First. That the salts are derived from connate sea waters of early Paleozoic age, which were buried with the sediments. The salts are believed to be taken into solution by the meteoric waters derived from the height of land to the west and northwest and then to be brought to the surface by the fault. In stating these views, few have previously given proper attention to the carbonic acid gas, but Dr L. C. Beck, the author of the valuable report on the Mineralogy of New York in 1842, refers it to a source deep within the earth and was correct in his views regarding the solubility and physical behavior of the gas.

Second. That the salts and gas are tapped from some deep-seated source by the fault along which they mingle with the relatively pure surface waters. This view is most definitely stated in a paper by Mr Charles F. Fish which was read before the American Pharmaceutical Association at a meeting in Saratoga Springs in 1880. The volcanic character of salts and gases were mentioned by Mr Fish.

The writer of the report has first sought to compare the dissolved salts with those known to exist in the sea water of today and with the composition usually attributed to the Paleozoic sea. The suggestion is made that the oceanic waters doubtless covered the valley of the Hudson and probably the site of the springs in Post-glacial time.

Judged by their connate representatives elsewhere, the Paleozoic sea is believed by those who have written upon the subject, especially Dr T. Sterry Hunt, to have had more calcium chlorid than sodium chlorid. If so, its connate waters can not account for the Saratoga Springs waters which have vastly preponderating sodium chlorid.

When compared with modern sea water, whether its samples are taken from the most concentrated portions like the Red Sea or the most dilute embayments like the Gulf of Bothnia and the Baltic, or from the open ocean, analogies fail because the dissolved salts of the sea are singularly uniform and all carry in analyses of their evaporated salts 7⅝ per cent SO_4 and from two to five times as much magnesium as calcium; whereas, in the salts from Saratoga waters, when based on analyses believed to be of genuine samples, there is rarely .1 of 1 per cent SO_4 and the calcium exceeds the magnesium. If we recast the Saratoga analyses so as to reduce the calcium to sea water values, on the assumption that it has been dissolved from the limestone, we thereby raise the proportion of sodium from 5–10 per cent above the sea water values. There are other differences believed to be irreconcilable so that it seems impracticable to support the derivation of the salts from sea waters whether connate or Postglacial.

A second and very serious objection lies in the fact that in the Champlain valley there is an indefinite number of faults with greater sections of Paleozoic strata next them and with greater artesian head near them than is the case at Saratoga, but with no development of brine springs.

The carbonic acid gas is next taken up. All its possible sources are passed in review and the conclusion is reached that it is due to igneous forces, of which expiring volcanic action is the usual and most probable one. The existence of the volcanic plug at Northumberland ten or twelve miles east of Saratoga Springs, is cited. That sodium and other chlorids are derived from volcanoes is shown to be a matter of observation.

The conclusion is reached that the source of the salts and the gas, and doubtless of some of the water, is deep seated and while

some may rise directly along the fault, the probable source is beneath the slates to the east of Saratoga. The waters are believed to be impounded beneath the tight slates and following up the dip are tapped off near the fault.

Artesian pressure from the northwest may aid their emergence and probably dilutes their concentration.

The mapping of the *Schuylerville* quadrangle which has been carried forward by Doctor Ruedemann has presented extraordinary difficulties as the region is one where the essentially homogeneous "Hudson river shales" predominate and which the exactitude of stratigraphy requires to be resolved into their essential units. The Canajoharie, Snake Hill and Normanskill formations are all determinable in this mass of shales and sands and have been now delimited on the map. Along the eastern edge of the sheet the Georgian formation, reaching in from the east and occupying the mountainous region, and the belt of supposed Trenton limestone at the foot of the mountains, were mapped. It was found that the Georgian rocks are overthrust on an almost horizontal plane over underlying rocks of later age, the Beekmantown, Trenton, Normanskill and Snake Hill series. This style of mountain making involving such tremendous overthrusting, though recognized in some other mountain regions, has not before been determined as existing in the Appalachian region of New York.

In the "Trenton" limestones of this region a quite impressive fauna has been found which indicates that the limestones are of Fort Cassin age and the fault breccia (the latter both in its pebbles and matrix) carries species of the Rysedorph Hill conglomerate near Albany, and is thus indicative of Atlantic origin in contrast to the Trenton fauna of central New York and the west. The Beekmantown beds are so distinct from those of the Champlain valley that they will be provisionally termed the Bald Mountain limestone.

In the shale region of the *Mohawk valley* work was continued in the resolution of the shale units which have been referred to as the Canajoharie shale, Indian Ladder beds and the Snake Hill beds. The two former terms were mentioned and defined in my report of last year. The Snake Hill beds compose a thick formation of shales, grits and cherts of lower Trenton age typically exposed on Snake hill, Saratoga lake. The fauna and position of these shales indicate that they overlie the Normanskill shales and probably belonged to the eastern or Levis basin. In connection with this work has been

the further exploitation of an eurypterid fauna in the Schenectady shales, the discovery of which was referred to last year.

Field work on the *North Creek* quadrangle which has been in charge of Prof. W. J. Miller was concluded by the survey of the northern portion of the area during the season of 1911. In general the geology is much the same as that of the southern portion of the quadrangle which was referred to in my last annual report, but a few additional features deserve notice.

The greatest single mass of syenite-granite extends from south to north across the quadrangle as a belt from six to ten miles wide, and in it are a few Grenville masses or inclusions of considerable extent. This great igneous rock belt is flanked on either side by large areas of Grenville rocks through which occasional mountains of syenite or granite protrude. The protrusion of these igneous masses to heights of from a few hundred to even two thousand feet above the surface of the Grenville, affords very strong evidence of a decidedly irregular surface of the syenite-granite bathylith just after it was cooled. In some cases faults along one or possibly two sides of the mountain masses have accentuated the height of these igneous rocks, but unless we postulate faults with elliptical or nearly circular strikes, it is evident that much of the present irregularity has been due to the irregularities on the surface of the bathylith at the time of cooling.

Eleven diabase dikes and more than fifty gabbro dikes or bosses have been found within the borders of the quadrangle, and these dikes show a decided tendency to arrangement into groups. The two largest gabbro bosses, each measuring about a mile long and from one-half to three-quarters of a mile wide, have been found in the northern portion of the region. One of these shows interesting effects of contact metamorphism along a wide zone where the gabbro breaks through pink granite. In another case a long narrow diabase dike breaks through a small boss of gabbro and shows excellent contact with chilled diabase margins.

In general the Grenville, being a much weaker formation, occupies the valleys, but in the north there are several well-defined exceptions to this rule and the Grenville extends to the summits of small mountains.

The very interesting occurrence and origin of garnets, in a number of mines in the northern portion of this quadrangle and the one just west, have been carefully studied in the field and laboratory studies are now being made.

A part of the field season was devoted to a detailed survey of the northwestern portion of the *Lake Pleasant* quadrangle. Not enough work has been done to justify any general conclusions for the quadrangle but, in the region so far examined, the Grenville series is only scantily represented, the few small areas noted being not much more than inclusions in the igneous rocks. Only one outcrop of crystalline limestone has been observed.

The great rock masses are syenite (augitic to hornblendic), granitic syenite, granite (pink to gray), and granite porphyry. These rocks all appear to be differentiation products of the same cooling magma. They grade from one type to another so frequently that drawing the boundary lines in such a rough, wooded country is difficult work.

Another rock encountered in fairly large masses is a fine-grained, gray to pinkish gneiss which, at times, shows suggestions of a banded structure. The relation of this rock to the others has not yet been satisfactorily determined.

No gabbro or diabase dikes have been noted, but the occasional gabbro boulders in the vicinity of Lake Pleasant indicate that this rock occurs not far northward.

Valcour Island. The detailed study and survey of this island in Lake Champlain, its rocks and their contents, its origin and bearing on the general history of the lake basin, have been carried forward by Prof. George H. Hudson.

Southeastern New York. During the past year there has been issued Doctor Berkey's important bulletin on the Geology of the New York (Catskill) Aqueduct which has been in large demand from engineers and other students of practical geological problems. The continuation of the aqueduct operations has afforded opportunity to examine the many tunnels and open cuts now nearly at maximum development and to make comparison with the conclusions of earlier explorations. This has been done with considerable care, with particular attention to sections where detail of structure could be worked out. It is only fair to say that there have been no wholly unlooked for conditions yet discovered. The geological formations and structures and conditions already described and based upon preliminary explorations, need little modification from the completed work. It is possible, however, now to class a great many items as facts that have heretofore been given as interpretations, and many details can now be added. The existence of several mud-filled caves in the limestones of the Rondout valley to greater depth than one

hundred feet below sea level has been proven. Faults and minor folds are still more numerous throughout the region than could be seen on the surface. Decayed conditions in crush zones, and in porous layers favorably situated, are known to exist to great depth locally and at depths of less than three hundred feet there are many narrow zones of rock in such condition. Rarely, near the surface, there are extensive occurrences of residuary matters. The tunnel near Garrison in the Highlands passes through over five hundred feet of such rock still preserving the typical formational structure, but so soft that it requires as substantial timbering as would so much glacial drift.

It is the deep explorations, however, that promise the most additional data. The courses of deeper water circulation and its effect on different rock formations are shown at many places. The granites beneath the Hudson river at Storm King mountain show strain to such extent that, in certain zones, slabs crack off from all surfaces as soon as exposed. This rock is penetrated at a depth of one thousand one hundred feet below sea level and all but about five hundred feet of the distance from one side to the other has been exposed. No noteworthy crush zone or fault or other special weakness line has yet been discovered in that section, but jointing is strong and abundant.

The tunnels show more clearly than the surface exposures the intrusive nature of the granites of the Highlands. One new belt of interbedded limestone and associated quartzite schist has been exposed by the aqueduct open cuts. Simple chemical tests on a great many samples of Fordham gneiss from New York City explorations have shown a much wider occurrence of lime carbonate in them than was formerly suspected. Many layers not connected with limestones at all carry a strong lime content.

A hurried reconnaissance and comparison has been made of the granite and limestones of the vicinity of Mounts Adam and Eve in the *Goshen quadrangle* and of the belt toward Franklin Furnace. The granites of that district are strictly of intrusive character. They cut and include older gneisses which themselves contain interbedded limestone layers in every way comparable to those of the region along the Hudson. A short reconnaissance of a small area in the Franklin quadrangle mapped as Pochuck gneiss was made for purposes of comparison with the Hudson river district.

In *Orange county* Dr Henry B. Kümmel has made observations which have an important bearing on the tectonic structure of the

crystalline hills and on the correlation of the Paleozoic stratigraphy with that of New Jersey. This region is one which has been previously studied both in its broader features and in some of its special details but Doctor Kümmel has brought to his examination of it long and exact acquaintance with the geology of New Jersey along the region of the Appalachian uplifts. Incidentally this work has afforded very considerable data for the areal mapping of the region. Doctor Kümmel reports as follows:

Overthrusting of the crystalline rocks. The region south of Greycourt is characterized by a number of isolated masses of gneiss which rise abruptly to notable heights above the surrounding shale country. Northeast of Greycourt is another line of similar hills but less massive and lower than the former. All of these larger gneiss masses have certain topographic features in common which are significant of the structural relations. Both eastward and westward slopes are steep and in places even precipitous. On the west the "Hudson River shale" extends part way up the slope and usually forms a narrow shelf along the mountain face. This shelf commonly attains its greatest elevation along the central portion of the hill and declines gently toward the northern and southern ends. Its inner (eastward) margin is marked by outcrops of gneiss usually rising above the shelf as a low ledge, but sometimes forming cliffs thirty or forty feet in height, above which the slope to the summit is more gradual. Toward the northern and southern ends of the hill the bordering gneiss ledge swings eastward as the shelf of "Hudson River shale" decreases in height. Viewed in profile from the north or south, the contact of the gneiss on the shale and its descent to the east as the end of the hill is approached is clearly shown by the topography.

The "Hudson River beds" within a quarter of a mile of the contact, dip 30° to 50° to the southeast, i. e. toward the gneiss at angles which accord fairly well with the inclination of the thrust plane. Locally the shale beneath the gneiss is minutely crumpled and contorted, even the finest laminae being closely folded as a result of the lateral compression when it was overridden by the crystalline rocks. The gneiss within several feet of the contact is often greatly crushed and traversed by many minor thrust planes which dip southeast at slightly varying angles. Many of these thrust planes are polished and slickensided.

The eastward swing of the contact between shale and gneiss with decrease in elevation, the crushed and slickensided condition of the

gneiss along the contact, and locally the crumpled state of the shale would be sufficient evidence to demonstrate that the gneiss had been overthrust upon the shale, even if the actual contact were not visible at a number of places.

The general trend of both the thrust plane and of the normal fault or faults which limit the gneiss on the east is east of north. At intervals another series of faults, trending northwesterly, intersect and dislocate the former. These are probably also normal faults along which the offset has usually been to the right as one faces the fault plane. In this they correspond to the great majority of the faults which intersect the magnetic iron ore bodies of northern New Jersey.

The relative age of the faults is plainly indicated. The thrust faults are the oldest, and the cross faults, i. e. northwest-southeast trend, are the youngest. The northeasterly trending normal faults are intermediate in age, although not necessarily much older than the northwest faults. Their absolute age is not so readily determined. In northern New Jersey there is evidence that the early movements in the Appalachian revolution which marked the close of the Paleozoic era were in the form of thrusts and that later the beds were folded, the thrust planes themselves being involved in the folding. By analogy it is assumed that the thrust planes in Orange county were formed at the same time as those farther south, particularly since Siluric and Devonic strata are involved in the movements. The normal faults are correlated with the movements, which raised, tilted and faulted the Triassic beds in the region only a few miles to the east and brought about the close of that period of sedimentation.

Correlation of Devonic strata in the New York and New Jersey areas. In 1901, Kümmel and Weller[1] described, under the term "Newfoundland grit" a thick-bedded, fine-grained conglomerate below and a white to greenish sandstone above, having an estimated thickness of about two hundred fifteen feet. The basal portion, so far as exposed, is composed of white quartz pebbles from one-fourth to one-half an inch in diameter, usually set somewhat loosely in a silicious matrix, so that the rock is of open texture and friable. Locally, however, the interstices are filled with a silicious cement and the rock is decidedly quartzitic. These coarser beds grade upward into a hard, greenish, thin-bedded sandstone, above which are

[1] Kümmel and Weller, Annual Report of the State Geologist of New Jersey, 1901.

outcrops of a black argillaceous shale, the Cornwall shale, carrying a Hamilton fauna. In New Jersey this grit forms a narrow belt parallel to the outcrops of the Longwood shale (Siluric), but separated from it by the Decker Ferry limestone which has been correlated by Hartnagel and others with the Wilbur limestone and the Rosendale cement beds of the upper part of the Salina of New York. The base of the grit has not been observed in New Jersey, and although its outcrops are nowhere far removed from the probable occurrence of the Decker Ferry limestone, there is always a concealed interval between them, so that the beds immediately subjacent are unknown.

On the basis of a small fauna found by Weller at two localities, one in the coarser beds and the other in the finer and upper layers, the formation was referred by the authors cited to the Onondaga, although some previous workers (Merrill, Darton and others) had regarded it as Oriskany. It is the lowest Devonic formation recognized in the New Jersey portion of the Green Pond area. Owing to a ruling by the board of geologic names of the United States Geological Survey, this formation has been called the Kanouse sandstone in several of the recent geologic folios.

The formations which immediately underlie the Kanouse (Newfoundland) sandstone of the New Jersey area are well exposed in a relatively new section at Highland Mills, New York. This section described by Clarke[1] is from the base upward as follows: (1) thin-bedded sandstones (Port Ewen beds?) 55 feet; (2) heavy-bedded sandstone (Oriskany) 13 feet; (3) thin-bedded blue sandstone, 14 feet; (4) heavy-bedded sandstone lighter in color and becoming coarser upward, 230 feet (these beds represent the Esopus and Schoharie grits). The highest beds exposed at Highland Mills are a few feet of thick-bedded white quartzite and conglomerate exactly like the basal beds of the Kanouse sandstone as exposed at Newfoundland, New Jersey and west of the southern end of Greenwood lake, and as the latter have been referred to the Onondaga as determined by Weller, the uppermost beds of the Highland Mills section may be so regarded.[2]

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[1] Clarke, J. M., N. Y. State Museum Memoir 9, pt. 2, p. 137.

[2] While the Onondaga limestone stage may be represented in the Kanouse sandstone, it seems a nearer expression of the exact relations that the Kanouse sandstone be regarded as the expression of the coarsely clastic earlier deposits of the Onondagan division, that is, a near equivalent to the Schoharie grits. J. M. C.

Darton, Ries, Hartnagel and others have described a fine-grained conglomerate at the north end of Pea Hill, near Cornwall, and six miles north by east of Highland Mills. Lithologically it is identical with the conglomeratic beds at the extreme top of the section at Highland Mills and with the conglomeratic portion of the Kanouse (Newfoundland) formation of New Jersey. It has the same stratigraphic position as those beds and underlies the Cornwall shale of Pea Hill, although not in actual contact with it. No doubt is entertained as to its being the same formation, in spite of the fact that certain characteristic Oriskany fossils have been reported from it. The rock is very hard and fossils are few and not readily obtained. It is not at all impossible that they have been wrongly identified as was the case with the earlier finds in the similar beds near Newfoundland which were regarded as Oriskany.

In this connection it should be noted that the Oriskany strata identified by Clarke in the Highland Mills section carry many fossils in large masses and are heavy-bedded, fine-grained sandstones with no trace whatever of pebble-bearing layers or conglomerates, and that they lie 244 feet below the layers of grit and conglomerate at the top of the section.

At Pea Hill there is a covered interval of considerable width between the New Scotland limestone and the conglomerate heretofore regarded as Oriskany, so that there is room for at least a portion, if not for all the beds of the Highland Mills section, even if we do not consider the possibility of the loss of a part of the section by faulting.

In view of all these facts there can be no question that the conglomerate at Pea Hill should not be referred to the Oriskany, but to the Onondagan, including perhaps the top of the Schoharie. If it contains Oriskany fossils as previously reported (which perhaps may be doubted in view of the fragmentary and poorly preserved nature of the material) their presence may indicate a return of the Oriskany fauna at a later period, as suggested by Hartnagel.[1]

Along the western margin of the Green Pond-Skunnemunk mountain syncline there is a series of disconnected outcrops of a coarse white quartz conglomerate. They vary in size from small exposures of a few square yards to ledges a mile in length and a hundred feet or more in height. The most conspicuous of these are (1) north of Bull Pond, (2) south of Oxford Depot, (3) several small areas a mile east of Oxford Depot, and (4) south and (5) southwest

[1] Hartnagel, C. A., N. Y. State Museum Bulletin 107, 1907, p. 43.

of Woodcock Hill. With perhaps the exception of several small areas east of Oxford Depot these conglomerates are without question parts of one formation, their separation being due to the numerous faults which have affected this portion of the area. Although no fossils have been found in them they have been correlated by several writers with the conglomerate at the north end of Pea Hill near Cornwall and assigned to the Oriskany. Lithologically they resemble the lighter colored phases of the Shawangunk (Green Pond) conglomerate much more than they do the conglomerate at Pea Hill, in that they are coarser, denser and less frequently present the open texture which often characterizes the latter. Where best developed they greatly exceed it in thickness. Moreover recent road excavations have at several points revealed the presence of the Longwood shales which normally overlie the Shawangunk (Green Pond) conglomerate, in close proximity to and above these conglomerates. It seems therefore, necessary to correlate them with the Shawangunk (Green Pond) conglomerate, and not with the conglomerate at Pea Hill. As already pointed out, the latter is to be correlated with the Kanouse (Newfoundland) grit of the New Jersey area and is Onondagan and not Oriskany in age.

Manhattan and Staten Island. Pursuing a definite plan for the acquisition of all new data relating to the geology of New York City, Doctors Kemp and Berkey have brought together details exposed in the course of municipal and private construction undertakings, and Doctor Hollick has continued his records relating to the special geologic features of Staten Island.

Long Island. Professor W. O. Crosby's report on the general geology of Long Island, will, it is believed, be soon in readiness for publication.

SURFICIAL GEOLOGY

The study of the origin and history of the surface deposits in the Schenectady region has been carried forward to completion by Dr J. H. Stoller and his report is now in press. Over about one-half of the area of the *Schenectady quadrangle* the deposits were made in the glacial lake known as Lake Albany. These deposits consist in general of an underlying bed of evenly stratified dark clays grading into overlying sands. They are well exhibited in the vicinity of Schenectady where the Mohawk river has cut into the mass, forming a crescentic bluff in which a thickness of about one hundred feet of clay covered by some fifty feet of sand is exposed. This mass is a portion of the extensive delta deposit which stretches southeast-

ward from Schenectady to the Hudson valley, the surface of which forms the sand plain crossed by the New York Central railway between Schenectady and Albany.

The Lake Albany deposits cover the greater part of the eastern and northeastern portions of the sheet, the materials here representing sediments laid by waters moving in the general valley of the Hudson. An interesting locality is that of the region of Round lake. This lake lies in the middle of a depression, some four square miles in areal extent, the bottom of which is largely strewn with boulders while the slopes consist of the clays and sands of the Lake Albany deposits. The depression is probably a portion of an old rock valley, as interpreted by Woodworth, but its present topographic features are due chiefly to the erosive action of powerful currents of water which, soon after Lake Albany began to subside, swept across this region. These currents were a portion of the Mohawk flood of the Lake Iroquois stage of that river, diverted northward through Ballston channel and thence easterly across the Round lake region.

The elevation of the undisturbed Lake Albany deposits is about three hundred fifty feet in the locality of Schenectady. In the southeastern portion of the quadrangle the elevation is less but along the eastern border of the sheet, north of the Mohawk river, the deposits rise to a gradually higher level and in the plain east of Malta show an elevation of three hundred eighty feet.

A glacial lake not hitherto reported is that named Lake Alplaus which occupied the lowest portion of the extensive basin lying between the slope of the Glenville hills on the west and the Charlton hills on the north. The deposits made in this lake have an elevation of four hundred twenty feet. Lake Alplaus resulted from the accumulation of morainic materials at the time of the recession of the ice sheet, forming a barrier behind which glacial waters became ponded. The greater portion of this moraine, especially in the locality southeast of the village of Burnt Hills, exhibits the characteristic features of morainic topography.

In general the uplands portions of the quadrangle above the levels of the lacustrine deposits are covered with unmodified till. Some interesting evidences of extensive ice erosion were observed. Most notable is that of the broadening and deepening of the Ballston channel, a great troughlike depression which extends from near East Line southeasterly to the present Mohawk valley near Aqueduct. This channel is preglacial in origin, following a line of

highly tilted rock-strata, but there are convincing evidences that it was greatly modified by ice erosion. It was through the gouging action of moving ice with inclosed fragments of rock that the bed of Ballston lake, a long narrow body of water which occupies the lowest portion of the channel, was formed.

On account of the weathered condition of the underlying shales, where exposed, glacial scratches are infrequent but they were observed in five localities. The directions of the scratches ranged from 22° west of south, about one mile northeast of the city of Schenectady, to 57° west of south at a locality near the western boundary of the sheet.

It has long been known to geologists that the gorge of the Mohawk beginning at Aqueduct is postglacial in origin. An interesting part of the present work was the determination of the conditions under which the gorge was formed. When Lake Albany was at its greatest development the Mohawk river discharged into that body of water at about four miles northwest of Schenectady and built a delta out into the lake as referred to above. It was probably at this time that the preglacial channel of the Mohawk was filled up with deposits. When Lake Albany began to subside the delta emerged as land surface and the Mohawk currents became confined within a channel conforming with the present basin near Schenectady. A spillway became established across the rocks below Aqueduct. At the same time the impeded waters, everywhere pressing against the slopes of the basin, gradually forced a passage into the southern end of Ballston channel. These northward moving currents emerged from the channel near East Line, there discharging into Lake Albany. The two outlet streams from the Mohawk basin to Lake Albany were maintained as long as, through erosion, their beds were kept at the same level. This equality of erosive effects was probably determined by the circumstances that the rate of subsidence of Lake Albany was no greater than the rate of lowering of the beds of the two streams by erosion. At length, however, owing to the greater extent of bed of the Ballston stream, it failed to deepen its channel as rapidly as its rival and its waters were drawn off in favor of the Aqueduct course of the Mohawk.

A beginning was made by Doctor Stoller in mapping the surface deposits of the Saratoga quadrangle. A considerable portion of this area appears to be covered by materials laid down by Lake Albany waters at different stages of their existence. The work will be continued into the following season.

The closing phase of glaciation in New York has been particularly studied by Professor Fairchild somewhat in conclusion of his many years of work on the postglacial waters and deposits of this State. Professor Fairchild has submitted a summary of his observations on this subject which is incorporated herewith:

Recent surveys by the Canadian government have given us reliable altitudes along the international boundary in the towns of Havelock and Franklin including the Covey hill district of northern New York. This locality is critical for the study of the Pleistocene phenomena associated with the close of glaciation in New York, and for determination of the ancient water planes and their deformation in the St Lawrence and Champlain valleys.

The summit of Covey hill is 1120 feet above ocean, which is 90 feet higher than the figure used by Doctor Gilbert and by Professor Woodworth in his description of the Mooers quadrangle (N. Y. State Museum Bulletins 83, 84). Taking advantage of the precise altitudes now available on the Canadian side of the boundary the glacial drainage features and the marine shore line have been mapped in the area connecting the Champlain and St Lawrence valleys, revealing an interesting history that is given here in brief outline.

The glacial Lake Iroquois found its second outlet at the Covey gulf, the channel being at somewhat over 1000 feet altitude. The level of the lake and river is estimated at 1025 feet altitude, which is 565 feet higher than the lake level of the previous outlet at Rome.

The highest bars of the marine beach are at least 525 feet above sea, and they retain this height around the north slope of Covey hill and westward until they reenter New York, at Boyd's lines, five miles north of Chateaugay village. This shore has been traced in practical continuity as far as Potsdam, where its altitude has fallen to 480 feet. The correlation of this shore line with the beaches in Jefferson county is now positive.

The deformation of the Iroquois plane furnishes evidence of the marine origin of the Covey hill beaches. The Covey gulf channel at the time it carried Iroquois outflow must have been as low at least as the Rome outlet, or 565 feet lower than it is now (1025–460). The depression of Covey hill by 565 feet would carry the top of the Covey beaches (now 525 feet altitude) 40 feet below sea level. This excess of submergence will be explained later.

The slow lifting of the land out of the sea produced a remarkable series of close-set bars. On the east and west road near the north edge of the Mooers quadrangle forty-two bars are counted in a distance of one and one-fourth miles and through a vertical fall of only 165 feet, or from 525–530 down to 365 feet. Similar series of crowded cobble bars are noted on all the roads in Canada which traverse the beach; at Covey Hill P. O., Stockwell, Maritana, Franklin Center, Rockburn and Brooklet. Some stretches of the marine shore in New York are as heavy and impressive as the

Cobble bars on marine shore

Upper figure. Northwest of Franklin, Quebec. Looking west along the seventh bar from the summit.

Lower figure. Northwest of Franklin, Quebec. Looking east along the eighteenth bar from the summit.

Boulder moraines

Upper figure. One-fourth mile south of Shea's lines, and one and one-half miles south of Covey Hill post office.

Lower figure. Excavation in summit of Cobblestone hill, three miles northwest of West Chazy.

stronger portions of the Iroquois beach, notably a stretch of about ten miles in the town of Lawrence, St Lawrence county. In contrast some sections require close examination to determine the upper limit of wavework.

The declination of the shore line from Franklin, Quebec, to Potsdam, N. Y., and on to near Watertown, is slightly less than one foot a mile. On the east side of the Covey hill salient, in the Champlain valley, the beach declines at the rate of about three feet a mile in direction some 20 degrees east of south. The isobars seem to lie about 10 degrees south of west, which makes the direction of steepest uplift about 10 degrees west of north. This explains the nearly level attitude of the beach in Canada.

The Iroquois shore is now approximately known throughout its reach from Covey gulf to Watertown, being located chiefly by the heavy deltas on the principal streams, but with good bars or shore line features at several localities. The deformation of the Iroquois plane in northern New York is 2.4 feet a mile in the southwest direction, using the highest bar at Watertown (733 feet). Using the lower series of bars (671 feet), which probably represents the later or Covey gulf plane, the deformation is 2.9 feet a mile. The beach is nearly parallel to the marine shore, the intervening distance being five to seven miles.

Between the Iroquois and the marine planes are two other water-levels. The continuity and importance of these intermediate planes was first recognized by Professor Chadwick, who has specially studied them on the Potsdam and Canton quadrangles. The explanation of these lakes necessitated reexamination of the slopes of Covey hill and study of the Pleistocene features in the Champlain valley.

It appears that the waning Labradorian ice sheet lay close about the Covey hill promontory, as if reluctant to yield its hold on New York. Because the flow movement was from the northeast the ice body pressed with more force on the east side of the salient, so that when the Iroquois waters, creeping northward in the St Lawrence valley between the ice border and the Adirondack highland, finally reached the low pass across Covey hill, they found the ice still closely investing the Champlain side of the highland. The outflow at Covey gulf, successor to or contemporaneous with the Rome outlet, was held up at high levels and produced heavy and characteristic iceborder drainage phenomena. A river as large as the St Lawrence, with ice for its eastern channel wall, flowed southeast across the towns of Mooers, Altona and Beekmantown and stripped large areas of Potsdam sandstone bare of drift, as described by Woodworth in his papers on the Mooers quadrangle. In its earliest flow the Altona river (as we propose to call the flood) had very little fall at Covey hill, but curved southeast and then south some eight miles to the valley of the north branch of the Big Chazy river, then southeast and south some fifteen miles until it poured its flood into the glacial Lake Vermont (named by Woodworth) at

an elevation of about 800 feet. The enormous volumes of coarse detritus carried by the Altona river was first thrown into Lake Vermont southeast of West Beekmantown, at and south of the hamlet known as Beartown, where an area of several square miles is buried under coarse delta stuff which might be mistaken for moraine. The courageous farmers have tried to clear the land by building huge cobblestone fences around small fields, which fields are yet masses of cobble.

As the ice sheet weakened and the Altona river was lowered on the land slope Lake Vermont was also falling and the stream detritus was dropped at about 700 feet altitude two miles north of West Beekmantown and three miles southwest of West Chazy. The closing phase of the drainage was into Lake Vermont at about 600 feet, producing heavy deposits at Cobblestone hill, northwest of West Chazy.

The areas of stripped and eroded rock are the most striking and peculiar features of the region. These are the Stafford's rocks between Covey gulf and Cannon Corners, with altitude 900–765 feet; Blackman's rocks, southeast of Cannon Corners, about 800–700 feet; and the Altona bare rocks, 900–620 feet. The channeling erosion by the Altona river has produced a striking series of north and south valleys south of the bare rocks. The correlation of the bare rock areas with the Covey gulf was correctly predicated by Woodworth.

While the ice front was holding the river flow along the lower edge of the Altona rocks the ice weakened on the north slope of Covey hill so that Lake Iroquois found escape around the promontory and was lowered to the level of the Altona river, toward 700 feet. This stream control, along the east side of Pine ridge, established for a time a lake in succession to Iroquois, which we propose to call *Lake Emmons* (after Ebenezer Emmons whose district in the first geologic survey of the State covered this territory, and who first drew attention to Covey gulf). For a relatively brief period Lake Emmons occupied the Ontario basin, producing some conspicuous delta sand plains. It left a few strong beaches, near Altona, at Cannon Corners and at the extreme northwest corner of the Mooers quadrangle, the altitudes ranging from 740 down to 680 feet. The strength of these bars, formed in a narrow lake, is surprising and is not satisfactorily explained, unless we can attribute the effective wave action to the calving of small icebergs or the slumping of the ice front in shallow water.

This sequence of events connected with the Covey gulf river explains why no high cataract cliff was formed at the east end of the gulf. All the flow except possibly the very latest was held up to high level and forced south by the obstructing ice front. Even the greatest drop could be only 250 feet, or to the level of Lake Emmons. A swamp filling at the Emmons level occupies the old valley below the gulf. Probably the outflow of Iroquois was diverted from the gulf to the north side of the hill while the ice front was holding the

Altona stream flow at high levels, so that no great volume of water ever fell through the vertical interval from Iroquois (1000) to Emmons (750).

When the ice barrier was removed in the Altona district Lake Emmons was lowered into Lake Vermont, and the latter lake in its turn occupied the St Lawrence and Ontario valleys. This expanded lake will be called *Vermont-New York*. Its deltas are broad on the Grass, Raquette, St Regis, Salmon and Chateaugay rivers, and Chadwick has found some good shore line features.

Eventually the ice sheet weakened on the Vermont side of the Champlain embayment and Lake Vermont-New York was drained down to sea level and oceanic waters took possession of the Champlain, St Lawrence and Ontario valleys at the same time.

The Covey gulf outlet of Iroquois to have been effective must have been at least as low as the Rome outlet, but now it is 565 feet higher. The postmarine uplift at Covey hill, that is since the ocean was admitted there, is definitely 525 feet according to the figures of the Canadian topographic map. This excess of at least 40 feet submergence represents the amount of uplifting of the district during the interval of time between the extinction of the Covey gulf river and the construction of the earliest marine beaches. This interval covers the duration of the downdraining of Iroquois to Emmons and the periods of life and downdraining of Emmons and Vermont-New York. It would appear that this interval was only a small fraction of post-Iroquois time.

The vertical interval between the shore lines diminishes southward along with the altitudes. For the St Lawrence valley the altitudes and intervals are given approximately, in the following table, subject to future correction.

Comparison of shore lines in the St Lawrence valley

LAKE	COVEY HILL		PARISHVILLE–POTSDAM		FULLERVILLE–GOUVERNEUR [1]		WATERTOWN	
	Altitude	Interval	Altitude	Interval	Altitude	Interval	Altitude	Interval
Iroquois.....	1 025	275	920	225	815	183	733	(153)
Emmons.....	750	100	695	95	632	87	(580)	(80)
Vermont-New York	650	125	600	120	545	110	(500)	(100)
Oceanic.....	525	.....	480	.....	435	.....	400	.....
Total interval..		500		440		380		333

[1] The figures for the Fullerville-Gouverneur section and those in parentheses are calculated and theoretical.

INDUSTRIAL GEOLOGY

Building stone. During the past field season an inspection of the quarry localities was undertaken by the assistant state geologist with the aid of Mr R. W. Jones of the staff. It was found

impracticable to extend the operations in the few months available beyond the crystalline rocks of the Adirondacks and southeastern New York, but it is aimed eventually to cover the quarries of the whole State. Sufficient observations and materials are in hand for a detailed description of the granites and other silicate rocks, which is now being prepared. According to the plan to be followed the information will include results of physical tests, chemical analyses and microscopic examination of representative specimens, so far as they can be secured or made for the special purpose of the report.

The last complete work on the building stones of the State is that by Smock which was published over twenty years ago.

The great expanse of crystalline rocks included in the Adirondacks and the outlying region affords a variety of quarry materials, some of which are suitable for building and ornamental uses and are classed by the trade under the general term of granite. The most widespread types comprise granites proper, syenites and anorthosites. Gabbros, dike rocks and gneisses have more limited applications but are serviceable for local purposes of road improvement, engineering construction, or rough work in which durability rather than an attractive appearance is the essential requirement. The development of the quarry industry in the Adirondack region has been retarded by lack of proper transportation facilities. Though these are much improved, compared with the conditions twenty years ago, there is less security for new enterprises by reason of competition from the established industries of other states. Only for materials of exceptional beauty or quality can any extensive sale be anticipated under present conditions.

One of the better known granites of this region is found in the outlying area of crystalline rocks exposed along the St Lawrence river from Clayton to Alexandria Bay. The rock is called Picton granite in Cushing's recent report on the St Lawrence region but the general trade term is Thousand Islands granite. It outcrops over parts of Wellesley and Grindstone islands, as well as many of the smaller islands in the river, and has a characteristic bright red color and a texture varying from coarse to fine. It has been quarried quite extensively for building, monumental and paving stone. It ranks with the best of American red granites. Picton island is the main source of present supply; a fine grained variety found there is distinguished by its beautiful pink color.

An area of red granite which hitherto has not been mapped or

described is found in the towns of Fine and Pitcairn, St Lawrence county, probably extending also into the adjacent part of Lewis county. It is traversed for several miles by the Carthage and Adirondack Railroad, in the stretch from Harrisville to Benson Mines. It is undoubtedly one of the largest bodies of massive granite in the Adirondacks. Compared with the Thousand Islands granite it has a lighter color and more acidic composition. The color and texture vary from place to place, but there is an abundance of sound and uniform material in the exposures which occur on the slopes and summits of ridges that have been denuded of soil by forest fires. Both in its situation and general character the granite seems to offer opportunity for exploitation, at least to supply some of the nearer markets.

Another characteristic stone of the Adirondacks that has possibilities for quarry operations is the green syenite which recent field work has proved to be of very general occurrence. In most outcrops it shows laminated textures, but residual cores with the original massive arrangement of the minerals are found in places. One of these, noted in the report on Adirondack magnetites, outcrops at Ausable Forks where quarry work has been recently undertaken on several properties. The syenite is too somber in color for most building purposes and its sale is practically restricted to the monument trade. Its unusual color, a dark lustrous green when polished, and its capacity for taking the most delicate designs, which it shows in strong relief, have attracted very favorable notice.

Some varieties of the Adirondack anorthosite, particularly of the granulated lighter-colored phases, are adapted to architectural work, though never used very extensively for such purposes. The vicinity of Keeseville affords many exposures from which most of this material has been taken. An area just south of Ausable Forks, now under development, yields a medium-gray uniform stone resembling granite in its general appearance. The results of experimental tests indicate that the anorthosite of this region is one of the best fire-resisting stones anywhere found.

In the southeastern crystalline area of the Hudson Highlands there is a considerable range of quarry materials, including granites, diorites, diabase and gneisses, but the better grades suitable for building and ornamental purposes are rather restricted in variety and occurrence. These are found in the local granitic intrusions which have broken through the country gneisses, or else in the

residual more massive portions of the gneisses themselves which are derived from earlier plutonic eruptives. Some of the granite intrusions belonging to the former class are those near Lake Mohegan, Garrison, New Rochelle and Pine Island. The Yonkers gneiss, a slightly laminated pink granite, and the Storm King gray gneissoid granite have been quarried quite extensively. In commercial importance the Palisades trap or diabase outranks all the other quarry materials from this section, though it is used solely as crushed stone.

Feldspar and quartz. In connection with the inspection of the granite quarries opportunity has been given to visit many of the pegmatite occurrences which accompany the crystalline rocks in the Adirondacks and southeastern New York. As sources of quartz and feldspar the pegmatites have considerable economic interest, particularly with reference to the local pottery industry which would derive some advantage from having supplies close at hand. At present practically all of the pottery spar and quartz is brought in from other states, the local production being limited mostly to the commoner grades. The inquiry is still in progress but will be completed as soon as practicable and the results prepared for publication.

Mineral statistics. The annual review of the mines and quarries for the year 1910 showed a total production by these industries valued at $35,400,257 or a little more than the aggregate reported for the preceding year. Activity was most noticeable in the early months and was followed by a period of dulness and depression, so that as a whole the year was not specially prosperous. In some departments, however, notable gains were made. The amount of iron ore hoisted from the mines reached the highest total on record, slightly exceeding one and a half million gross tons. The outputs of portland cement, gypsum, natural gas and salt also made new records. The effect of these increases on the total was partly counterbalanced by a falling off in clay manufactures and quarry materials, which constitute very important items of local production. In consideration of the general industrial situation during the year, the record may be regarded as very satisfactory.

Miscellaneous. Brief field trips were made during the year to various localities where new or interesting developments have been in progress.

The opening of new talc mines in the Gouverneur district and at Natural Bridge afforded opportunity to secure additional data on

the occurrence of that mineral and to increase the collections with some handsome specimens. The geological features of the deposits have already been described by C. H. Smyth, jr.

The occurrence of zinc in commercial quantity in the State seems to be fairly well established by recent exploration which has been under way near Edwards, St Lawrence county. At the time the deposits were inspected in the early summer, explorations had reached a depth of one hundred feet on one of the ore bodies, showing a continuous vein or band of zinc blende all the way. It is reported that active mining work will be started early next season. Besides the group of ore bodies near Edwards, which thus far have alone been developed to any extent, zinc blende has been discovered at several places in the stretch of country between Edwards and Sylvia Lake, where most of the fibrous talc is mined. The occurrence of the two series of deposits in close proximity, as well as in the same geological formations, may have some underlying principle and invites investigation.

Interest in the so-called gold sands of the Adirondacks has continued; many inquiries in regard to the matter, also samples of the sands from different localities, have been submitted during the year. It does not appear from any information obtainable that substantial progress has been made toward a commercial solution of the question and until this is reached there can be no basis for soliciting public support in the ventures. The recording of claims, meanwhile, is the most active manifestation of enterprise.

Office work. In addition to the research work the office duties have involved considerable correspondence on matters relating to the mineral resources of the State. So far as may be consistent it is aimed to make the information and facilities at hand available to the public. Samples of ores and minerals may be submitted for identification or an opinion as to their commercial value when it can be given without quantitative assay or chemical analysis. Investigations of the latter kind for private purposes are rather the function of commercial laboratories than of a geological survey.

SEISMOLOGIC STATION

In March 1911 the seismographic station completed the fifth year of service. From the start it has shown a degree of efficiency creditable to the mechanical equipment and has fully demonstrated the practicability of conducting observations of this kind under the somewhat peculiar natural conditions that obtain in its vicinity. The

instruments have been kept in continuous operation, except for brief stoppages necessary for cleaning the working parts and their readjustment. The list of records includes tracings of nearly all the important earthquakes that have occurred during the period, even covering such remote areas of disturbance as India and Central Asia. In general, therefore, the results secured at the station have been quite satisfactory.

With the approaching removal of the Museum offices and collections to the Education Building, the future maintenance of the seismographical work presents some questions for consideration and decision. If the station be continued in its present quarters a good deal of inconvenience and extra labor must be assumed by those in charge. Furthermore, the inability to exercise immediate supervision of the instrument may entail a marked loss of efficiency, compared with the previous service. The seismographs are still in good state of repair. At the time they were purchased they represented one of the most approved types, but since then larger and more sensitive instruments have been developed so that they are now somewhat inferior to those placed in the more recently established stations. Their future service, therefore, will probably be of less value comparatively than it has been in the past. On the whole it seems of doubtful expediency to undertake the expense of providing piers and other necessary adjuncts for their remounting in another place. The alternative that is practically presented in the circumstances is either to continue the existing station with the additional outlay of time and labor required for its future supervision and with correspondingly less returns in the way of results, or else to erect a new station at a convenient place, preferably in the Education Building, and equip it for the most efficient service.

The number of earthquakes recorded for the year ending September 30, 1911, was nine, as compared with nineteen in the preceding period, making a total of eighty-six separate disturbances since the station was established. The frequency, therefore, has shown a marked falling off during the year and as might be expected there have been relatively few microseisms. The small number of distinctive shocks reported throughout the world indicates at least a temporary halt in the succession of violent disturbances that extended altogether over several years and entailed such disastrous consequences in San Francisco, Valparaiso, Kingston, Northern India, Messina and Costa Rica. Most of the tracings have been of very small amplitude and from uncertain sources.

RECORD OF EARTHQUAKES AT ALBANY STATION, OCTOBER 1, 1910 TO SEPTEMBER 30, 1911

Standard time

DATE	Beginning preliminaries			Beginning principal part			Maximum			End			Maximum amplitude
1910	H	M		H	M		H	M		H	M		mm
November 6.....	3	43	P. M.	3	51	P. M.	3	52	P. M.	4	50	P. M.	12
November 26.....	12	01	A. M.	12	41	A. M.	12	47	A. M.	2	58	A. M.	10
December 10.....	4	52	A. M.	5	24	A. M.	5	35	A. M.	7	30	A. M.	5
December 13.....	7	05	A. M.	7	33	A. M.	7	40	A. M.	9	15	A. M.	10
December 16.....	9	47	A. M.	10	22	A. M.	11	00	A. M.	12	20	P. M.	5
1911													
January 3.....	6	43	P. M.	7	03	P. M.	7	18	P. M.	9	15	P. M.	120
May 4.....	6	48	P. M.	6	57	P. M.	.....			7	39	P. M.	½
September 16.....	10	40	P. M.	11	04	P. M.	11	07	P. M.	12	08	A. M.	5
September 22.....	12	06	A. M.	12	25	A. M.	12	26	A. M.	1	†	A. M.	3

November 6th. Apparently from a source within 3000 miles of Albany. North-south component most distinct.

November 26th. A microseismic tracing, very prolonged in its preliminary phase. May be a compound record, without definite relation between the phases.

December 10th. The record of a long-distance quake, probably 7000 or 8000 miles away. North-south component very weak.

December 13th. The beginning was probably earlier than the time given; no definite break existed between the first discernible tremors and the usual line.

December 16th. Only the east-west component represented. The record gives uncertain readings, perhaps from conflicting disturbances.

January 3d. The heaviest quake of the year, and comparable in its tracing to any of the shocks hitherto recorded. The east-west component was alone received, owing to a temporary stoppage of the second pendulum for repair. The center of the disturbance was in Russian Turkestan where it inflicted considerable damage and loss of life.

May 4th. Faint tremors showing no division between the preliminaries and principal part.

September 16th. A characteristic tracing of a small and distant shock.

September 22d. Appears to have originated in vicinity of Prince William sound, Alaska.

MINERALOGY

In pursuance of the investigation of the recent mineral occurrences of New York City, specimens from four localities have been studied in some detail, furnishing material for several short papers appearing

in this report. The material on which these notes are based has been kindly loaned for study by the New York Mineralogical Club and an individual New York collector. One new form for pyrite, two new forms for chrysoberyl and two new forms for pyroxene are recorded in these notes. In addition the minerals from Newcomb, Essex county, have been made the subject of a crystallographic study of some detail involving the species tourmalin, arsenopyrite and zircon. This study has added two new forms for tourmalin and two for arsenopyrite. Some preliminary work has been done on the occurrences of quartz in the Little Falls dolomite of the Mohawk valley as well as a large number of unpublished crystallographic determinations on New York City minerals and extralimital species.

The preliminary work connected with the installation of the collections in the hall of mineralogy involving the details and arrangement of cases has been completed. This work has been supplemented by the preparation of plans and schedules of types of cases involving the entire case installation for the Museum exhibits for the Education Building.

Several notable additions to the mineral collections have been made; barite from Frizington, England, a series of quartz specimens in groups and loose crystals from Amsterdam, Montgomery county, and others. The quartzes are remarkable in their sharpness and transparency and compare very favorably with the famous crystals from Herkimer county. These crystals occur in every instance implanted on a thin layer of chalcedony which separates them from the silicious limestone of the matrix and indicates a distinct change in the conditions of deposition of the silica between the two formative periods. A series of minerals was collected from Batchellerville, Saratoga county, prominent among which is a number of beryl crystals of unusual size; the largest of these measuring 27 inches in height by 10 inches in diameter. These beryl specimens, although not transparent are of a good characteristic green color, are fairly sharp in outline and constitute fine additions to the New York collection of minerals. From the same locality were obtained some unusually large crystals of muscovite which yield on cleavage, plates showing beautiful dendritic inclusions of magnetite and hematite arranged on the structural lines of the muscovite. A number of rose quartz specimens were also collected from Batchellerville, some of which are of a color and transparency suitable for cutting into spheres to show asterism.

An intestering series of specimens of titanite, associated with fluorite, was collected from Fine, St Lawrence county.

PALEONTOLOGY

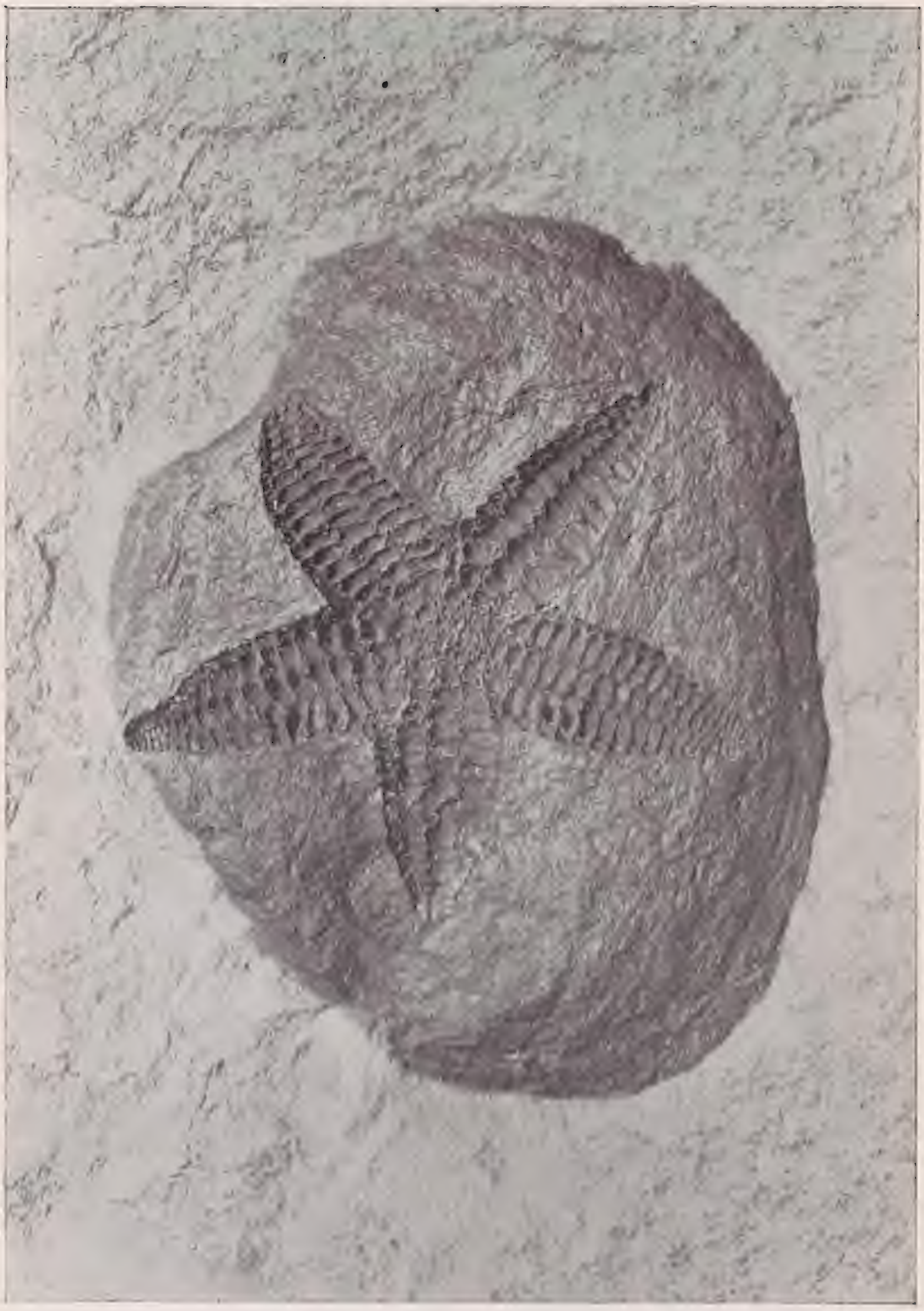
The collection of invertebrate fossils has been augmented by several interesting and valuable acquisitions from the field. Among these is an extensive series of the *Devonic fishes* from the beds at Migouasha in the Province of Quebec. In my report of last year I gave some special attention to the stratigraphy of these remarkable beds which probably surpass in the abundance and perfection of their remains any other known locality of Devonic fishes. An experienced collector has been engaged to watch the natural outcrops which are so exposed to the sea and weather as to break down readily and thus afford a continuous supply of the fossils. Some of the specimens thus acquired have been of a quality and interest to justify brief notice here, and there is given elsewhere in this report notice and illustrations of certain remarkable specimens prepared by Dr L. Hussakof.

The investigations of the *anatomy and distribution of the Eurypterida* to which of late years I have had occasion to make frequent reference have led to a final search for their remains in rocks of the State. The old and historic localities in Herkimer county have again been examined. Last year it was found desirable to remove part of the cellar walls of a barn near Crane's Corners, the rocks of which had been taken long ago from Eurypterus-bearing outcrops now no longer productive. That experience was attended with such success as to justify this year the removal of the remainder of this cellar wall, from which several hundred examples of these interesting creatures have been obtained. Further search for these remains in other parts of the State has revealed them in formations where they were least expected — in the Frankfort shales of the lower Mohawk valley and in the still earlier Normanskill horizon near Catskill. These have been discoveries of high paleontological significance and though the material from these earlier beds has not the superior preservation of the later examples, it has widely extended our knowledge of the history of the arachnid group to which the animals belong.

The explorations for these eurypterid remains in late years have been very fruitful and these accessions to our understanding of their geological range and significance, their anatomy and their abundance have been considerations which are fully considered in the monograph of the Eurypterida of New York, a publication which, after years of preparation, is about leaving the press.

A remarkable occurrence of Devonic starfish. The attention of the State Geologist was called to the occurrence of starfish in a sandstone on Mount Marion near Saugerties, through the courtesy of Professor Chadwick and the Rev. Thomas Cole, the discoverer. The sandstone proved to be of Hamilton age and carries some of the brachiopods and pelecypods which characterize that fauna in the central parts of the State. It seemed well to investigate this occurrence. The specimen sent in by the Rev. Mr Cole was a slab which had been broken from a ledge some years before and the locus of this outcrop was no longer known. Mr H. C. Wardell of the staff entered this field and after some days of search on the slopes of Mount Marion and of careful uncovering of concealed ledges, succeeded in finding the starfish-bearing rock. He then proceeded, with adequate assistance, to strip the layer bare and eventually uncovered an area of about two hundred square feet of the sandstone surface, this surface being bounded at the sides by slightly sagging crushed zones at which apparently the sandstone was displaced. The excavation was carried into the hill as far as practicable under the increasing overburden. This is a region where the rock layers have been subjected to some appalachian tilting but it is not yet known whether this productive sandstone is displaced beyond reach along the side lines or sags of crushing. From the sandstone layer as thus exposed were taken slabs and smaller specimens bearing not less than four hundred examples of the starfish Palaester eucharis Hall, a species described from the sandy shales of Madison county. It is probable that never before have so many starfish been found in an equal area of rocks of any geological age. Some views of specimens are here inserted to convey a conception of their number as well as of their fine preservation as external and internal casts.

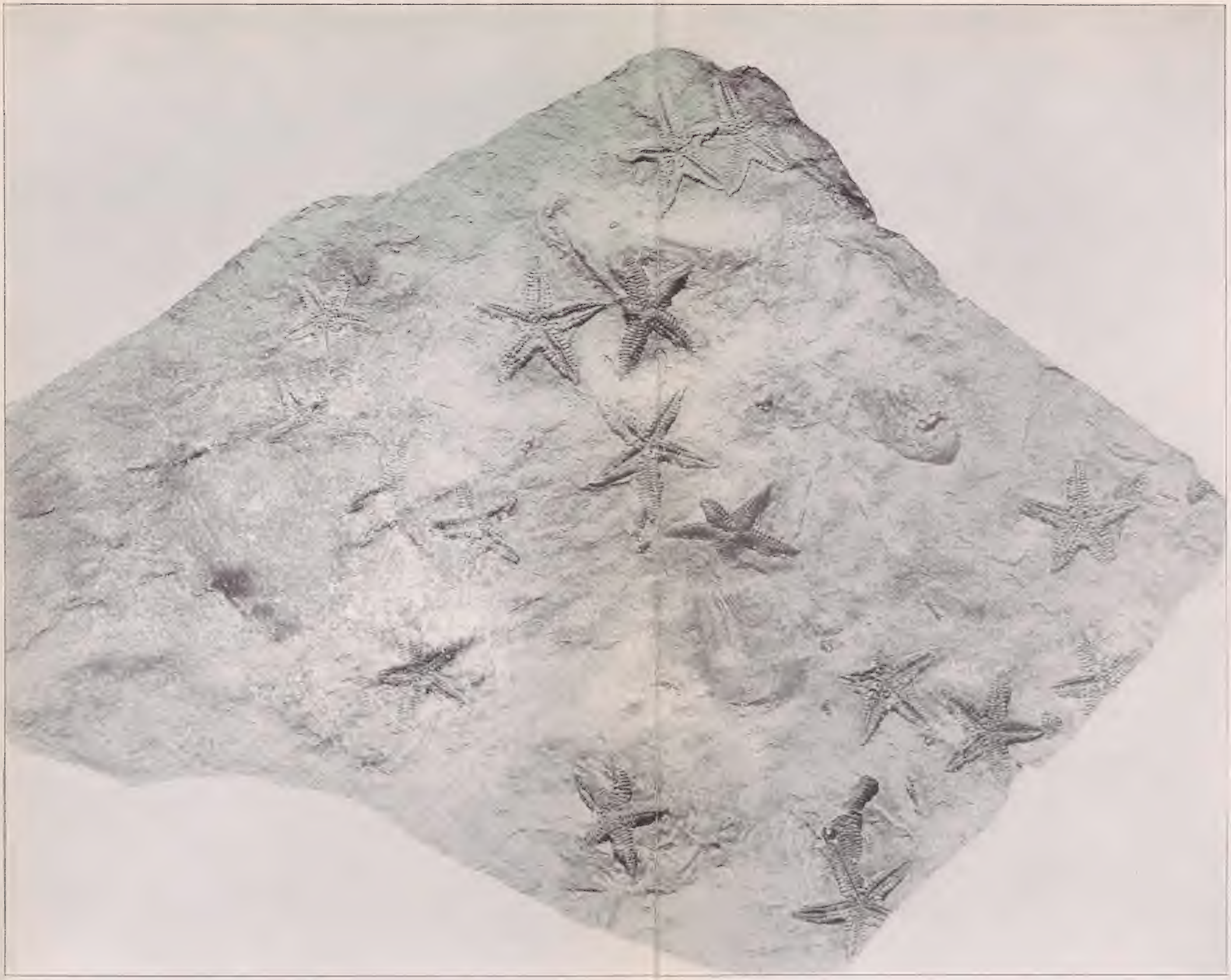
This occurrence is not only noteworthy for the marvelous abundance of the starfish but for the fact that their intimate association with the pelecypods or clams of the fauna not only suggests but seems to demonstrate the fact that the Palaeasters were feeding on the clams at the time they were overwhelmed in these sands. In present seas and existing oyster plantations the starfish is recognized as the most voracious enemy of the bivalves, especially in oyster beds that are free from much indrainage of land water and where the sea keeps to a normal salinity. To the oyster planter of the Long Island shores salvation lies only in eternal vigilance against these depredators and scores of bushels of stars are annually "mopped" from even small oyster fields. The mode of attack by the starfish on the



Palaeaster lying within a valve of Grammysia. Both are casts and the aboral exposure of the starfish indicates that its oral surface was against the inner surface of the clam shell.
Hamilton sandstone, Saugerties, N. Y.

Slab of Hamilton sandstone, much reduced. Showing three specimens of Palaeaster eucharis Hall, one of which has but four arms. Mount Marion, Saugerties, N. Y.

Part of a sandstone slab with valves of Grammysia and Pterinea in such close association with the starfish Palaeaster as to indicate the attack of the latter upon the clams. Hamilton group, Saugerties, N. Y.



A slab of Hamilton sandstone with remains of 20–25 individuals of Palaeaster eucharis Hall. Shells of Grammysia and Pterinea are visible at the side and near the middle of the slab. Saugerties, N. Y.

This slab of Palaeasters shows one lying within the hinge region of a Grammysia. Parts of other pelecypods are scattered over the rest of the rock in association with starfish. Saugerties, N. Y.

Slab of starfish (Palaeaster eucharis Hall). All exposing the oral surface. Reduced. Saugerties, N. Y.

oyster is now pretty well understood. Embracing the oyster with its flexible arms and placing its mouth against the edges of the valves it attaches itself by its suckerlike tube feet to one valve and the other, slowly but persistently and patiently pulling in opposite direction and against the strong pull of the bivalve's adductor muscles which hold the valves together. The slow long pull of the starfish tires out the stronger but less enduring oyster, the valves gradually yield and the incolant falls an easy victim to the eversible gorge of the starfish. A plantation of oysters is an invitation to the starfish to assemble on the ground, but their omnivorous appetite does not restrict them to this viand alone. Nothing edible is foreign to them. So in the ancient days of the Devonic, the clams and oysters, represented by the abundant Grammysias and Pterineas in these rocks, seem to have drawn the stars to this place, and then they were caught. Nearly every Grammysia or Pterinea found in this layer has a star in or on it, sometimes several about its edges in attitudes suggestive of attack and it is altogether reasonable to believe that the hostility between the starfish and the bivalves had fully developed at this early day in the history of the earth.

The structure, internal and external, of the Palaeaster is admirably preserved in these examples and among the specimens are a few which show the existence of only four, instead of the normal five arms.

Fauna of the Snake Hill beds. The organic contents of this formation have been worked out by Doctor Ruedemann and on the basis of their nature he allocates the formation to the lower Trenton The fauna is found in excellent development in shales, grits and cherts along Saratoga lake, and its composition indicates its affiliation with the eastern or Atlantic fauna of this time, rather than with the fauna of the interior basin of the continent.

The nature of this faunal assemblage is indicated by this list of species:

Dicranograptus nicholsoni Hopkinson
Diplograptus amplexicaulis Hall
D. amplexicaulis var. pertenuis Ruedemann
D. (Mesogr.) putillus Hall
Climacograptus scharenbergi Lapworth
C. spiniferous Ruedemann
Cryptograptus tricornis Carr. mut. insectiformis Ruedemann
Lasiograptus eucharis (Hall)
Glossograptus quadrimucronatus Hall mut. pertenuis Ruedemann
Corynoides calicularis Nicholson
Dawsonia campanulata Nicholson

Glyptocrinus sp.
Heterocrinus ? gracilis Hall
Cremacrinus sp.
Schizocrinus nodosus Hall
Carabocrinus cf. radiatus Billings
Edrioaster saratogensis nov.
Pontobdellopsis cometa Ruedemann
Paleschara ulrichi nov.
Pachydictya acuta (Hall)
Lingula curta Conrad
Leptobolus insignis Hall
Pholidops subtruncata Hall
Schizocrania filosa Hall
Plectambonites sericeus typus (Sowerby)
Plectorthis sp. cf. whitfieldi (N. H. Winchell)
Dalmanella testudinaria (Dalman)
Plaesiomys retrorsa (Salter)
Plectorthis plicatella Hall
Platystrophia biforata (Schlotheim)
Rafinesquina alternata (Emmons)
Clitambonites americanus (Whitfield)
Rhynchotrema inequivalve Castelnau
Parastrophia hemiplicata Hall
Cyclospira bisulcata (Emmons)
Zygospira recurvirostris (Hall)
Whiteavesia cincta nov.
W. cumingsi nov.
Orthodesma ? subcarinatum nov.
Whitella elongata nov.
Clidophorus ventricosus nov.
C. foerstei nov.
Ctenodonta levata (Hall)
C. declivis nov.
C. prosseri nov.
C. radiata nov.
C. recta nov.
C. subcuneata nov.
Lyrodesma schucherti nov.
Solenomya ? insperata nov.
Cuneamya acutifrons Ulrich
Archinacella orbiculata (Hall)
Cyclonema montrealense Billings
C. cushingi nov.
Clathrospira subconica Hall
Protowarthia cf. cancellata (Hall)
Pleurotomaria cf. lenticularis (Hall)
Murchisonia (Lophospira) uniangulata var. abbreviata Hall
Orthoceras tenuitextum (Hall)
O. lineolatum (Hall)
Spyroceras bilineatum (Hall)

Conularia trentonensis Hall
Pterotheca cf. canaliculata (Hall)
Eoharpes ottawaensis (Billings)
Trinucleus concentricus (Eaton)
Proëtus undulostriatus (Hall)
Triarthrus becki Green
Isotelus gigas Dekay
Acidaspis trentonensis Hall
Calymmene senaria Conrad
Pterygometopus callicephalus (Hall)
Ctenobolbina ciliata (Emmons)
C. ciliata var. cornuta Ruedemann
C. subrotunda Ruedemann
Lepidocoleus jamesi (Hall & Whitfield)
Turrilepas ? filosus Ruedemann
Pollicipes siluricus Ruedemann

Relation of the Portage fauna of western New York to that of the Domanik shales of Southern Timan in northeastern Russia. In my various papers which have been devoted to the discussion of the Portage (Naples) fauna and its distribution in western New York, there has been frequent occasion to point out the striking similarity between this very peculiar association of fossils and that found in the "Domanik" of northeastern Russia. My first references to this similarity date back some twenty years but these were based wholly on what had been made known of that distant region by Count von Keyserling who explored it in 1843 and published his account of the rocks and their fossils in 1846. Keyserling indicated the similarity in a very broad way but at that time the New York Portage fauna was not well understood from the brief account of it given by James Hall in 1843, nor was the Timan fauna itself comprehended until the materials brought in by the expedition to that country in 1899–1900, had been studied. While I was engaged in describing the cephalopods of the Naples fauna in detail (Naples Fauna of Western New York, part 1), Holzapfel was working out the cephalopods of the Domanik fauna and the two works appeared almost simultaneously, neither writer thus having the benefit of the other's observations. In part 2 of the writer's work under this title, there was occasion to refer at length to the remarkable similarities in the two faunas as indicated by Holzapfel's investigations. Although the remaining molluscan fauna of the Domanik beds was then but very partially known I indicated the very close similarities of these distant faunas, based on the evidence so far as then brought out.

During the year 1911 the lamellibranchs of the Domanik have been elaborated in detail by A. Zamjatin (Die Lamellibranchiata des Domanik: Mémoires du Comité Géologique. n. sér. livr. 67. 1911) and the very peculiar genera and species which compose this element of the Naples fauna, many of the genera not heretofore recognized outside of this assemblage in New York, have proved to be present in the fauna of the Domanik. There is a remarkable community of species which is supplemented by approximations to identity in other cases, all tending to show that the extraordinary similarity in the faunas indicated by Holzapfel's and my own studies of the goniatites is even surpassed by the agreement among the bizarre types of lamellibranchs. Lists of these species as they occur in these two regions are here inserted. The New York fauna appears to be much the more profuse but it is very probable that this fact is due to the more extensive collecting and longer study that have been devoted to it.

PORTAGE, NEW YORK (NAPLES FAUNA)	DOMANIK SHALES TIMAN, RUSSIA
Lunulicardium acutirostrum *Hall*.....	Lunulicardium sp.
L. ornatum *Hall*	
L. libum *Clarke*	
L. wiscoyense *Clarke*	
L. accola *Clarke*	
L. clymeniae *Clarke*	
L. eriense *Clarke*	
L. hemicardioides *Clarke*	
L. furcatum *Clarke*	
L. velatum *Clarke*	
L. finitimum *Clarke*	
L. sodale *Clarke*	
L. encrinitum *Clarke*	
L. pilosum *Clarke*	
L. bickense *Holzapfel*	
L. absegmen *Clarke*	
L. enode *Clarke*	
L. parunculus *Clarke*	
L. beushauseni *Clarke*	
L. suppar *Clarke*	
L. (Opisthocoelus?) transversale *Clarke*	
Pterochaenia fragilis (*Hall*).....	Pterochaenia fragilis (*Hall*)
P. fragilis (*Hall*) var. orbicularis *Clarke*	P. fragilis var. orbicularis *Clarke*
P. sinuosa *Clarke*	
P. perissa *Clarke*	
P. elmensis *Clarke*	

P. cashaquae *Clarke*	P. cashaquae *Clarke*
Honeoyea erinacea *Clarke*	P. timanica *Zam.*
H. major *Clarke*	P. tschernyschewi *Zam.*
H. styliophila *Clarke*	
H. simplex *Clarke*	
H. desmata *Clarke*	
Paraptyx ontario *Clarke*	Paraptyx uchtensis *Zam.*
Actinopteria sola *Clarke*	P. sp. n. *Zam.*
Leptodesma cf. rogersi *Hall*	
Posidonia attica (*Williams*)	
P. mesacostalis (*Williams*)	Posidonia mesacostalis (*Williams*)
P. venusta Münster var. nitidula *Clarke*	
Kochia ungula *Clarke*	
Loxopteria dispar *Sandberger*	
L. laevis *Frech*	
L. vasta *Clarke*	
L. intumescentis *Clarke*	
L. corrugata *Clarke*	
Ontaria suborbicularis (*Hall*)	Ontaria suborbicularis (*Hall*)
O. concentrica (*v. Buch*)	O. cf. concentrica (*v. Buch*)
O. pontiaca *Clarke*	
O. accincta *Clarke*	
O. clarkei (*Beushausen*)	O. cf. clarkei (*Beushausen*)
O. affiliata *Clarke*	O. tchernyschewi *Zam.*
O. halli *Clarke*	O. elegans *Zam.*
Euthydesma subtextile *Hall*	O. articulata (*Münster*)
Elasmatium gowandense *Clarke*	
Buchiola retrostriata (*v. Buch*)	Buchiola retrostriata (*v. Buch*)
B. ? livoniae *Clarke*	
B. scabrosa *Clarke*	B. scabrosa *Clarke*
B. halli *Clarke*	B. halli *Clarke*
B. conversa *Clarke*	
B. angolensis *Clarke*	
B. lupina *Clarke*	B. cf. lupina *Clarke*
B. cf. prümiensis *Steininger*	
Paracardium doris *Hall*	
P. delicatulum *Clarke*	
Praecardium vetustum *Hall*	
P. duplicatum (*Münster*)	
P. multicostatum *Clarke*	
Conocardium gowandense *Clarke*	Modiella aff. pygmaea *Hall*
Palaeoneilo constricta *Conrad*	
P. petila *Clarke*	
P. muricata *Clarke*	
P. brevicula *Clarke*	
P. linguata *Clarke*	
Leptodomus interplicatus *Clarke*	
L. multiplex *Clarke*	

The author we are citing speaks of other identities in these remote

faunas which will come to light as the Domanik material is more fully elaborated.

It is one of the noteworthy facts of our geological history that this singular Devonic fauna, in New York quite free of complications with its predecessors and successors, characterized by very peculiar organic types, should find its most exact reproduction, under like conditions of sedimentation, in the almost antipodean region of the Domanik, separated from New York by 129° of longitude.

III

REPORT OF THE STATE BOTANIST

Since the date of my last report specimens of plants not before represented in the State herbarium have been collected in thirty counties of the State either by myself, my assistant or correspondents and contributors. These specimens represent one hundred species and varieties. Many of them are comparatively recent introductions to our flora but are apparently well established. Among the added species are twenty-eight fungi which are considered new or hitherto undescribed species. A list of these species and varieties is subjoined.

New to the herbarium

Acer carolinianum *Walt.*
Aecidium atriplicis *Shear*
Anthyllis vulneraria *L.*
Armillaria pinetorum *Gill.*
Artemisia frigida *Willd.*
A. gnaphalodes *Nutt.*
Ascochyta imperfecta *Pk.*
A. rhei *E. & E.*
Boletus ballouii *Pk.*
Camarosporium maclurae *Pk.*
Centaurea maculosa *Lam.*
Cercospora medicaginis *E. & E.*
Cercosporella terminalis *Pk.*
Clavaria subtilis *Pers.*
Clitocybe fumosa brevipes *Pk.*
C. hirneola *Fr.*
C. sinopicoides *Pk.*
C. splendens (*Pers.*) *Fr.*
C. tuba *Fr.*
C. tumulosa *Kalchb.*
Coniothecium chromatosporium *Cd.*
Coprinus domesticus (*Pers.*) *Fr.*
Coronospora angustata *Fckl.*
Cortinarius albidipes *Pk.*
Cortinarius phyllophilus *Pk.*
C. purpurascens *Fr.*
Coryneum disciforme *K. & S.*
Cytospora rhoina *Fr.*
C. salicis (*Cd.*) *Rabenh.*
Dasyscypha sulphuricolor *Pk.*
Deutzia scabra *Thunb.*
Diplodia spiraeina *Sacc.*
Diplodina medicaginis *Oud.*
Flammula sulphurea *Pk.*
Fusarium pirinum (*Fr.*) *Sacc.*
Ganoderma sessile *Murr.*
Gloeosporium valsoideum *Sacc.*
Gutierrezia sarothra (*Pursh*) *B. & R.*
Gymnolomia multiflora (*Nutt.*) *B. & H.*
Haplosporella ribis *Sacc.*
Hebeloma sinapizans *Fr.*
Helvella capucinoides *Pk.*
Hendersonia grossulariae *Oud.*
Hydnellum peckii *Banker*
Hygrophorus recurvatus *Pk.*
H. sordidus *Pk.*
Leptosphaeria distributa (*C. & E.*)

Marasmius epiphyllus *Fr.*
Melanconis alni *Tul.*
Mycena atroumbonata *Pk.*
M. metata *Fr.*
Naucoria arenaria *Pk.*
Oenothera muricata *L.*
Omphalia offuciata *Fr.*
Ophiotheca vermicularis (*Schw.*)
Peniophora tenuissima *Pk.*
Periconia pycnospora *Fres.*
Peronospora trifoliorum *DeBy.*
Pestalozzia adusta *E. & E.*
P. funerea *Desm.*
P. longiseta *Speg.*
Phacidium lignicola *Pk.*
Pholiota rigidipes *Pk.*
Phoma amorphae *Pk.*
P. bacteriophila *Pk.*
P. leprosa *Pk.*
P. smilacis *B. & J.*
Physcia granulifera (*Ach.*) *Tuck*
Polyporus melanopus *Fr.*
Polysaccum pisocarpium *Fr.*
Psilocybe fuscofolia *Pk.*
P. polycephala (*Paul.*)
Poria pulchella *Schw.*
Ramularia karstenii *Sacc.*
Rubus glandicaulis *Blanch.*
Sagedia cestrensis *Tuck.*
Septoria aquilegiae *P. & S.*
S. dianthi *Desm.*
S. malvicola *E. & M.*
S. mirabilissima *Pk.*
Sphaeronema minutulum *D. Sacc.*
Sphaeropsis amorphae *E. & B.*
S. maclurae *Cke.*
Spongipellis occidentalis *Murr.*
Stagonospora carpathica *Baeuml.*
Steccherinum peckii *Banker*
Steganosporium fenestratum (*E. & E.*)
Stigmina populi (*E. & E.*) *Pk.*
Teichospora trimorpha *Atk.*
Thyridium pallidum *E. & E.*
Tricholoma boreale *Fr.*
T. planiceps *Pk.*
T. subsaponaceum *Pk.*
T. subsejunctum *Pk.*
Trimmatostroma salicis *Cd.*
Uromyces spartinae *Farl.*
Ustilago hypodytes (*Schl.*) *Fr.*
Verbena stricta *Vent.*
Vermicularia hysteriiformis *Pk.*
Volutella buxi (*Cd.*) *Berk.*

Specimens of 183 species and varieties not new to the herbarium have been added. These represent some new form or variety of species already represented or are better specimens than the older ones.

Several species of wild mushrooms have been tried for their edible qualities. Of these eight species and varieties have been approved, and colored figures of natural size and revised descriptions have been prepared. This makes the number of New York species and varieties of edible mushrooms 213. Investigations have been made showing that some edible mushrooms vary decidedly in flavor.

In an effort to locate the chestnut bark disease which has proved so destructive to chestnut trees in some parts of our State, two trips were made, one to Sand Lake, Rensselaer county, and one to Cooperstown, Otsego county. Both of these visits were unsuccessful in finding any trees affected by the disease, though chestnut trees were common in both places.

In June a visit was made to Peacock marsh, near Averyville in Essex county, and a list of the species of flowering plants observed growing on the marsh was made.

The peculiarities of the season have been shown to have a marked influence upon the abundance of the crop of mushrooms and in some species upon the time of their appearance. The drought of summer delayed the appearance of some species till the fall rains came. Then their appearance combined with that of the usual autumnal species made an unusually abundant crop. The influx of specimens sent to the office for identification was never before so large. It necessitated considerable evening work and even a large number of specimens were unavoidably laid aside for future examination. Among the extralimital specimens examined twenty-three new species and varieties of fungi were found and descriptions of them written. Among the most remarkably delayed species is that of the conical morel, which usually appears in May and June. A colony of it was found near Boston, Mass., growing during October and November.

The work of preparing simple revised descriptions of our New York species of certain genera of fungi has been so well received and strongly commended by correspondents who find them very helpful in their mycological studies that it has been continued the past year. The genera Clitocybe, Laccaria and Psilocybe have been treated according to the plan previously followed. The first mentioned genus is one of special difficulty both because of its large number of species, their variability and different appearance at different ages and their close resemblance in many cases to each other. The genus has been divided into several genera by modern mycologists but we have preferred to follow mainly the better known Friesian and Syllogian arrangement. Our New York species as here understood number sixty-four after taking out the few species here placed under Laccaria.

IV

REPORT OF THE STATE ENTOMOLOGIST

The State Entomologist reports the appearance in late May of a large brood of the *periodical Cicada* or so-called *seventeen-year locust.* This was of much popular interest and an entomological event of some importance. A hitherto unknown colony was located near Amsterdam and much learned through the cooperation of many local observers respecting the present distribution and relative abundance of this insect in New York State. A fine series of photographs showing the transformations to the adult was obtained. Despite the warnings of earlier years, a number of young orchard

trees had been set in the vicinity of abundant Cicada colonies and, as a result, were severely injured.

During the period covered by this report, Miastor larvae were discovered by the Entomologist, their biology ascertained in large measure, their amenability to laboratory conditions demonstrated, and owing to the value of this information to teachers, a discussion (illustrated with a series of photomicrographs) of *pedogenesis* in this insect and its allies was included as an appendix to the Entomologist's report for 1910. Subsequent studies have confirmed the observations referred to above and have shown a wide distribution for Miastor.

Fruit pests. The experiments with the codling moth or apple worm were continued in the orchard of Mr W. H. Hart of Poughkeepsie and in those of Messrs Edward Van Alstyne and William Hotaling at Kinderhook. Special pains were taken to secure uniform plots of ample size and to see that the treatment was thorough. Each plot, as last year, except in the case of Mr Hotaling's orchard, consisted of forty-two trees, the fruit from the central six alone being counted. The relative value of one, two and three sprayings, and also of one application made three weeks after the blossoms dropped, was ascertained. The results compare closely with those obtained in 1909 and go far to show that the conditions in 1910 were exceptional. One thorough application last season resulted, in the case of trees bearing a fair crop, in from over 98 to more than 99 per cent of worm-free fruit. This should prove most encouraging to the fruit grower, since the work was done under practical conditions which can be duplicated in almost any section. Assistant Entomologist Young assisted in the field work, classified the wormy fruit and computed the tabulated data.

The work of 1911 with the *codling moth* has been correlated with that of the two preceding years and affords the most comprehensive data yet secured as to the possibilities with one spraying under varied conditions. These results should be of practical value in enabling the fruit grower to determine for himself the advisability of spraying more than once in any season.

Observations by the Entomologist show that the *San José scale,* while a serious fruit tree pest, is being generally controlled, though some fruit growers are not entirely successful, in fact due in large measure to difficulties in treatment. Some of the latter are excessively large or inaccessible trees, adverse weather conditions at the time the work should be done or defects in equipment. The con-

centrated home-made or commercial lime-sulfur washes were used largely and mostly with very satisfactory results.

The peculiar linear series of eggs so frequently seen on apple and pear bark have been identified as those of the *notch wing*. The usually rare *Say's blister beetle* was exceptionally numerous. Two small fruit insects, the *raspberry Byturus* and the *garden flea* were studied at Milton, the former proving somewhat injurious.

Gipsy moth. The discovery of a gipsy moth colony at Lenox, Mass., while not entirely unexpected, was something of a shock to our extensive agricultural interests. A personal examination satisfied the Entomologist that the insect was brought there with trees and shrubs purchased a few years ago in eastern Massachusetts. Nothing but the closest inspection and the adoption of most rigid precautions will prevent the early establishment of this pest in New York State. Judged solely from an economic standpoint, there can be no question as to the advisability of keeping this insect out of the State as long as possible. We have assembled during the year a series of preparations designed to facilitate the recognition of this pest in any stage. Several of these have been reproduced as excellent photomicrographs and will be of great service in identifying this species.

The Entomologist visited the territory in eastern Massachusetts infested by this insect and found the residential area, as a whole, in excellent condition though there were extensive tracts of forest land badly infested. The ultimate spread of this pest is inevitable and the Federal authorities have accomplished much in retarding its dissemination by keeping the roadside trees of the principal thoroughfares free from the pests. Marked progress is being made in the work of introducing parasites and natural enemies which it is expected will shortly prove of material service in checking this injurious pest. This however is no justification for not adopting every other reasonable measure for preventing the spread of this destructive caterpillar. The state of Connecticut has made excellent progress in handling its gipsy moth problem.

Brown-tail moth. This species, while not so destructive as the gipsy moth, has become established in Williamstown, Mass. Since both sexes of the moth fly readily, it will probably not be long before this pest appears somewhere in New York State. The winter nests are so characteristic that there should be little difficulty in identifying the insect and at the outset preventing excessive multiplication. Careful inspection of nursery stock should prove an effect-

ive barrier to its being introduced with trees and shrubs. The observations above relating to the parasites of the gipsy moth apply equally to the natural enemies of the brown-tail moth.

Shade tree pests. The Entomologist investigated conditions in a number of communities and found exceptionally severe and widespread injury by the *elm leaf beetle*. The defoliation was so general, in connection with the work of previous years and the severe droughts of earlier seasons, that many trees have succumbed or are likely to die in the immediate future unless radical measures are adopted for their better protection.

There seems to be great difficulty in securing efficient treatment, even if the equipment be adequate. This defect has been pointed out and, with a fuller understanding on the part of those compelled to solve the problem, we look for materially better results another season. The elm leaf beetle is not such a serious pest in Europe, and it would seem, in view of the probable continuance of the severe injury of the last few years, to be due in part at least to changed conditions, as though a serious effort might well be made to secure natural enemies, since they appear to be very effective checks upon this beetle in European countries.

The *cottony maple scale* and the false maple scale occasioned repeated complaints, owing to their effect upon hard and soft maple, especially in the vicinity of New York City. An unfortunate condition developed in the city of Mount Vernon. Several hundred hard or sugar maples were seriously injured or killed, following the application of one of the commercial miscible oils in early spring. An investigation convinced the Entomologist that the trouble was due to the material applied, the injury being greatly aggravated by subsequent cold weather retarding growth and producing conditions favorable for penetration by the oil. We must therefore classify early applications of oily preparations as dangerous to hard maples.

The extended outbreak by the *green maple worm* was investigated and must be partly charged to the general destruction of birds and a consequent scarcity of the insectivorous species. Investigations by Zoologist W. G. Van Name showed that nine species were feeding upon the caterpillars, while seven others were in the vicinity, probably for the same purpose. A relatively slight increase in the number of the birds would doubtless have prevented the defoliation of the trees. The *spiny elm caterpillar* and the *white-marked tussock moth* are two other shade tree pests which were excessively abundant and the subjects of much correspondence. The ornamental birches are

being rapidly destroyed by the pernicious *bronze birch borer,* the depredations of which were detected the past season in the eastern part of the State.

Forest pests. Injuries by insects to forests have greatly increased during recent years. The *hickory bark borer* has destroyed thousands of magnificent trees in the vicinity of New York. The investigations of the Entomologist showed that this nefarious pest had destroyed many hickories at Tivoli. A warning circular was issued and widely copied by the local press. The *two-lined chestnut borer,* probably breeding first in fungus-affected chestnut, invaded nearby oaks at Old Westbury. This outbreak was studied and appropriate repressive measures advocated. Damage by this species was also reported from Garden City. The severe though local injury by the *locust leaf beetles* at Syosset and Jericho received personal attention. The exceptional abundance of the *maple leaf cutter* at Lake George was also investigated.

Flies and mosquitos. General interest has been maintained in the *house fly* campaign. The Entomologist prepared several popular notices and experimented in a limited way with a fly trap. The results with the latter, while beneficial, were not entirely convincing. He investigated a local *mosquito* problem at South Salem and had the satisfaction of learning that the execution of his recommendations resulted in the speedy disappearance of the pests. Many localities in the State are suffering needless annoyance and, in some cases, illness because mosquito breeding pools are ignored. One case came to his notice where malaria developed following the employment of Italians in a locality previously free from this disease.

Gall midges. The studies of the Entomologist in this interesting and important group have been continued as opportunity offered. A number of new species have been reared and described, and a table of food habits of the reared species and a generic synopsis of the entire group published. This family, composed entirely of small to minute flies and including a number of destructive forms, is an immense complex which could be grouped satisfactorily only after prolonged and careful microscopic studies. This has been accomplished and a monographic account of the family is now in manuscript.

Publications. A number of brief popular accounts of the more injurious species of the year were prepared by the Entomologist and widely circulated through the agricultural and local press. His extended contributions, aside from the report for last year, are:

Summary of the Food Habits of American Gall Midges; A Generic Synopsis of the Itonidae; Hosts and Galls of American Gall Midges, and New Species of Itonidae. His more important publications, forty-four in number, are listed in his report, which also contains detailed accounts, with special reference to control measures, of most of the injurious species mentioned above.

Collections. There has been a continued increase in the State collections. Most of the additions the past year have resulted from collections by the Entomologist's staff, some of the most desirable having been reared. Extremely large series of Miastor and Oligarces were obtained in this manner and will be available for exchange later. Specimens illustrating the habits and work of insects are being collected at every opportunity, since they are particularly valuable for economic and exhibition purposes. There have been substantial additions to the gall midges or Itonidae and they are now in very satisfactory condition. The pinned specimens were rearranged by Miss Hartman and this, in connection with the numerous microscopic slides, and the large assemblage of galls and other biological material, will prove invaluable to subsequent workers, especially as the collection includes a very large number of types.

The classification of the diversified material in the Museum and that daily coming to hand is necessarily slow and is a work which must extend over years. There is need of more assistance in carrying on the large amount of labor involved in the amassing of a thoroughly representative collection necessary for the maintenance of an adequate exhibit in the enlarged quarters afforded by the Education Building.

Three additions have been made to the series of plant groups designed for the exhibition of insects in their natural environment in the new quarters. These will add greatly to the attractiveness and pedagogical value of the enlarged exhibit collections now in preparation.

Assistant Entomologist Young has rearranged and identified the Muscidae, the species belonging to the coleopterous genera Telephorus and Podabrus, and has done considerable work on the snapping beetles or Elateridae, the parasitic flies, the Tachinidae, and a group of parasitic wasps, the Braconidae.

Miss Hartman has made nearly five hundred microscopical preparations of various species, mostly gall midges and scale insects, rearranged the pinned collection of scale insects and prepared a

special Cicada exhibit. She also has given much time to mounting, spreading and labeling the specimens.

Nursery inspection. The nursery inspection work conducted by the State Department of Agriculture has resulted in the Entomologist being requested to make a number of identifications and also recommendations in regard to the policy which should be pursued by the State. Most of the material submitted for name is in poor condition, may represent any stage in insect development, and is often from a foreign country. This work, though time consuming and laborious, is important, since the disposition of large shipments must depend in great measure upon his findings. The possibility of introducing the gipsy and brown-tail moths with nursery stock originating in territory infested by these pests, justifies a most careful examination of all such material and the adoption of every reasonable precaution.

Miscellaneous. A series of experiments planned by the Entomologist and conducted for the purpose of testing the value of heat as an insecticide, showed that the relatively moderate temperature of 120° F. is soon fatal to the common black cockroach so frequently seen in warmer parts of dwellings. Buildings equipped with ample heating facilities are adapted to this method of checking household and storeroom pests. Observations were made upon the hibernation and development of the rose leaf hopper. An interesting outbreak by an Iris borer was also investigated. Assistant Entomologist Young had charge of the heat experiments, being assisted in this by Miss Hartman.

The Entomologist, as in previous years, has been called upon to lecture upon injurious insects at farmers institutes, horticultural and other gatherings, information respecting shade tree pests, owing to their serious injuries this year, most frequently being desired.

Office matters. The general work of the Entomologist's office has progressed in a satisfactory manner. The correspondence shows a marked increase over that of last year; 2219 letters, 23 postals, 1014 circulars, 1623 packages were sent through the mails and 42 packages were shipped by express. As heretofore, there has been a most helpful cooperation on the part of all interested in the entomological work of the State.

V

REPORT OF THE ZOOLOGIST

The work of the zoology section has been conducted with regard to the exhibits which are to be expected in the new quarters, and with a view to preparing the collections now in the Museum for removal with as little injury and confusion as possible. Much of the zoological material, especially that which has been on exhibition, is of so fragile a nature that its safe removal can be accomplished only by careful handling and intelligent supervision at the time of moving. It has therefore seemed important to get the material that may be boxed up for handling by the ordinary methods of transportation packed as soon as possible, so that when moving attention may be given wholly to the fragile material. This policy has been consistently carried out during the fiscal year as far as other work would permit, with the result that large parts of the study and duplicate collections are now safely boxed up to stand rough handling and storage for as long as may prove convenient, without danger of injury or further deterioration.

Among other specimens, those that have been thus cared for are the corals (both duplicate and exhibition collections), the Mazatlan and Carpenter collections of shells, the bird eggs (exhibition and study collections), the bird skins, many of the duplicate shells, the bird nests, and most of the disarticulated skeletons and smaller osteological specimens. The majority of these were previously in storage, and though some of the corals and bird eggs were taken from the exhibition cases, the exhibits had not at the end of the fiscal year been so interfered with as to require closing the exhibition rooms to the public.

Incidental to this packing, as well as for the sake of discovering the needs of the Museum in the way of new specimens, and of caring for such specimens as might need it, the Zoologist has thoroughly overhauled the storerooms and storage closets. The bird skins, which on account of the loose construction of the cases in which they had been kept, were in poor condition, have mostly been cleaned, relaxed, and put in first-class condition before packing.

In preparation for the exhibits in the Education Building, the Zoologist has devoted much attention to plans for the arrangement and dimensions of the cases to be ordered, as well as to the details, methods and materials of construction which seem best adapted for the requirements of the Museum. Many of the mounted specimens

in the present collection have been carefully cleaned, and in many cases relaxed and improved or remounted, so that they will remain presentable for many years to come, and the expense and trouble of replacing them with new specimens may be postponed for a long time. To accomplish this, the taxidermist has installed a compressed air cleaning outfit and has made a plaster-lined chest for relaxing specimens, as well as a number of storage chests.

The large amount of work to be done in the Museum has prevented any field work by the staff, but additions to the collection have been made by purchase as far as funds were available, and to a less extent by exchange, or received as gifts. The moose group, consisting of three individuals, previously ordered from Ward's Natural Science Establishment, has been delivered to the Museum and placed in storage. The specimens are fine ones and unusually well mounted. Work on the other large groups ordered has also made progress. In the purchase of new material the want of specimens of the larger birds and animals has been kept in view, both because the collections have been deficient in good specimens of them and because of the importance of rendering the Museum interesting and attractive to the general public at the time of opening, and of adequately filling the large exhibition space.

Among the more generally interesting specimens acquired should be mentioned the materials (mounted young and old birds, nests, eggs and accessories) for arranging nesting groups of the larger and more conspicuous birds that breed in New York State, purchased from Mr S. H. Paine of Silver Bay, and Mr Fred Barker of Parker's Prairie, Minn., a group of opossums consisting of the mother and nine young, also some casts and models of reptiles and small cetaceans (porpoises and dolphins) from Ward's Natural Science Establishment, and several fine elk skins suitable for mounting, from Rhodes and Gilbert of Lander, Wyoming. In the material acquired this Museum has the basis of exhibits which will be hard to duplicate in view of the increasing rarity of many of the species.

Monograph of the New York Mollusca. Dr H. A. Pilsbry has continued his work on this subject and reports that the land mollusks are now completed in manuscript and good progress has been made on fresh water forms. The land snails have required very special attention for the reason that great progress has been made here and abroad in classification during the last twenty years, while there has been no critical examination of our northeastern fauna since Mr

Binney's work of 1878 (his Manual of 1885 being merely a reprint). This has necessitated considerable work in dissecting eastern forms to settle their generic affinities by the new standards. Much of this work has application far beyond the limits of New York and will thus give the report a wider than local interest. The examination of collections has added several species to the fauna, but a number reported from the State have been deleted, as they were found, when the specimens were traced, to be erroneous identifications. A few others reported from "Western New York" in reputable works still need verification.

VI

REPORT ON THE ARCHEOLOGY SECTION

The work of this section divides itself into two subsections, archeology and ethnology. In turn, these again divide into several distinct branches. To carry out the plans of the section the work involves both time spent in the field and in the office. Besides these various divisions of research and of labor, the work of the fiscal year just past has been divided between that necessary to carry on the ordinary requirements of the section and the special requirements of the Myron H. Clark Hall of Iroquois Ethnology. The additional labor brought about as the result of the Capitol fire and the destruction of the archeological and ethnological collections exhibited about the western staircase, has been heavy and consumed much of the time between March 29th and May 15th.

With a great increase in the correspondence of the section, together with the other work, activities have been taxed to the utmost.

Archeology. During the autumn of last year an interesting site was located in the town of Livonia, Livingston county. It was one of several examined during the year and found worth excavating. The site has long been known as that of a fort or village of the colonial period. The burial ground had not been found until located by our tests.

During July, August and September fifty-two graves were found and explored with good results. The graves presented some interesting problems and yielded some interesting and unique specimens. The excavations were conducted by Mr E. R. Burmaster, who for several years has acted as field assistant and whose expert services this year did much to bring about successful results.

A peculiar feature of the Lima site is that most of the graves were stoned up, but they did not resemble the stone graves of the pre-Iroquois culture, being deeper and not so well constructed. The poor condition of the skeletons and the broken pots were a result of poorly placed top slabs, which falling in had crushed the contents of the graves.

Only twelve of the fifty-two graves contained male skeletons. The few male skeletons which were found were of cripples or of aged men, none being of the warrior class. The females showed evidences of a hard life, there being broken bones and indications of osseous diseases, such as rheumatism and ankylosis. Ten of the skeletons lay on the right side, one of these being an infant in its mother's arms. One skeleton, also that of an infant, lay face up, the indications being that it had been buried in a cradle board. All the other forty-one skeletons were on the left side. There seemed to be no special orientation in the direction of the face or head, every point of the compass being used. The position of the body was uniformly (except in the case of one infant already mentioned) flexed, that is on the side with the legs bent and the knees drawn up toward the chest.

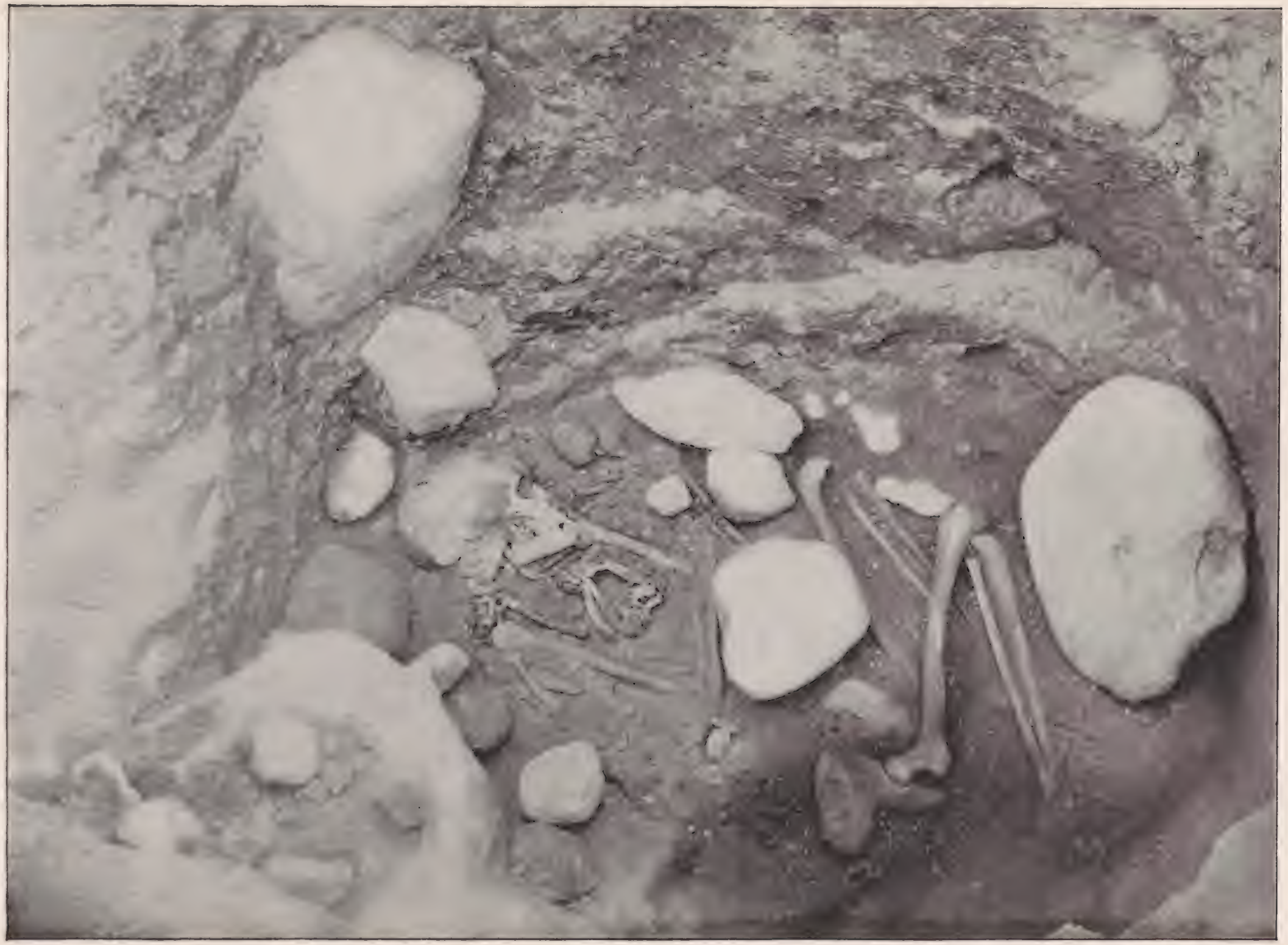
The age of this site is manifestly of the early colonial period, sheet brass having been found. That the period was rather early is shown by the fact that there were no brass kettles; all the European metallic material had been beaten up into ornaments. There were only a few glass and early trade wampum beads.

The burial site adjoined a village stronghold on the edge of a low bluff made by the intersection of two stream channels; one an ancient glacial stream or lake, now entirely filled by gravel or peat, and a more modern stream which as a small brook is still running.

The village site was only superficially examined because it is covered with a clover meadow valuable to the owner. The pits which were examined showed the usual bone and flint material with an occasional piece of metal and the columella of a sea shell.

By comparing the data of the graves of this site, that is those in the section examined, the Archeologist concludes that the burials are those of captives or slaves. Later investigations, however, may modify this conclusion.

The Archeologist and the members of the expedition are much indebted to the various members of the Livingston County Historical Society for assistance and other support in pursuing their investigations and surveys throughout the county. It is a source of much



Typical burial at the Lima site. Early colonial contact period.

Seneca burial found at Lima, 1911. The stone lay over and had crushed the head. Many bone implements were found in this grave.

gratification to find so many persons willing to cooperate in a work of this kind. We are under obligation to many for information and for their personal services as guides throughout the county.

Pending a more complete report of the season's work the following summary of the excavations at Lima is given:

BURIAL NUMBER	Depth	Dimensions	Face	Head	Side	Position	Sex	Condition	Objects in grives
1.....	28″	44x36″	N E	S W	left	flexed	M	crushed	broken pot, bracelet
2.....	44	48x42	E	S	L	"	F	skull c	none
3.....	28	48x42	S	E	L	"	F	skull c	brass spiral, wampum
4.....	30	42x36	N E	N W	L	"	F	skull c	none
5.....	30	48x36	N	W	L	"	F	skull c	none
6.....	40	48x28	N	W	L	"	F	good	shell beads, copper tube stone dice, etc.
7.....	36	42x30	N	W	L	"	M	poor	none
8.....	24	42–38	S	E	L	"	F	fair	bone comb, flints, etc.
9.....	50	50x36	N E	N W	L	"	M	fair	7 flint points
10.....	24	36x36	N	W	L	"	..	fair	4 copper rings
11.....	24	48x38	N E	N W	L	"	M	fair	2 flint points
12.....	24	54x26	N	W	L	"	M	fair	none
13.....	26	44x36	N E	N W	L	"	F	good	broken pot
14.....	42	48x36	N	E	R	"	M	fair	3 turkey mandibles
15.....	26	44x22	S	E	L	"	M	fair	none
16.....	36	36x22	E	N	L	"	F	fair	none
17a.....	36	48x32	S	E	L	"	F	fair	bone ornament
b.....	36	48x32	....	....	.....	"	Inf.	.....	
18a.....	30	36–22	up	W	on back	exten.	F	poor	none
b.....	....	.....	....	....	"	....	Inf.	.....	
19a.....	34	52x36	....	....	L	flexed	F	fair	none
b.....	....	.....	....	....	.....	"	F	.....	
20.....	48	39x28	N	W	L	"	F	poor	none
21.....	42	.....	N	W	L	"	F	fair	brass bracelets, beads, metal, shell, stone dice
22.....	48	45x32	S	E	L	"	M	fair	bone punch, arrow heads, flint chips, etc.
23.....	42	38x42	S	E	L	"	Inf.	poor	nothing
23a.....	37	42x26	N W	S E	R	"	F	poor	nothing
24.....	41	48x36	N	E	R	"	F	fair	necklace and armlet of shell beads
25.....	30	24x20	S	W	R	"	Inf.	poor	none
26.....	....	42x29	W	S	L	"	F	poor	none
27a.....	....	.....	N	....	R	"	F	fair	wampum and shell bead necklace, horn beads, brass rings attached
b.....	48	52x36	S	E	L	"	Inf.	poor	
28.....	....	.....	S	W	R	"	M	fair	3 antler punches, 3 bone awls
29.....	52	48x32	S	W	R	"	F	fair	3 clam shells, flint chips
30.....	34	50x32	N	W	L	"	F	fair	none
31.....	58	36x23	E	E	L	"	M	.....	none
32.....	41	44x32	S	E	L	"	F	poor	none
33.....	36	44x36	W	S	L	"	F	fair	none
34.....	52	33x38	S	E	L	"	..	good	none
35.....	42	48x37	....	....	.....	"	..	poor	none, only few traces of bone
36.....	41	28x26	E	S	R	"	..	poor	crushed pottery vessel
37.....	34	38x25	S W	N W	R	"	F	fair	none
38.....	42	26x16	N	W	L	"	..	poor	none
39.....	48	28x23	N	W	L	"	Inf.	fair	brass spiral, shell beads
40.....	34	44x30	W	S	L	"	F	fair	broken pot
41.....	34	48x32	N	W	L	"	M	fair	broken pipe, eagle bones
42.....	52	46x38	E	S	R	"	F	fair	1 glass bead
43.....	41	26x20	W	S	L	"	Inf.	fair	none
44.....	35	50x36	N	W	L	"	M	fair	none
45.....	48	48x31	S E	N W	R	"	M	fair	none
46.....	38	22x19	W	S	L	"	Inf.	fair	none
47.....	42	39x30	S	W	R	"	F	fair	none
48.....	37	36x29	N	W	L	"	F	poor	none

Ethnology. The Museum is still fortunate in being able to acquire occasionally good ethnological material from the Indians of the State and during the year a number of fine specimens have been added to our collections. The sources are already being exhausted by the many who are interested in Iroquois ethnology. As long as the Indians in New York remember the articles characteristic of their native culture, however, it is possible to have specimens made by them to illustrate the old form. This is especially necessary in the case of costumes.

Council gambling bowl of the Tonawanda Seneca. Collected by A. C. Parker, 1911

During the summer the council dice-bowl of the Tonawanda Seneca was secured. It is an ordinary maple gambling bowl such as the Senecas have long used but nevertheless an interesting specimen. It is some ten inches in diameter and four inches deep on the outside though the inside measures three. At present it forms the only specimen in the Museum, all others having been destroyed in the Capitol fire.

A number of baskets have been added to the collection. Two are of special interest in the matter of weave and decoration. The use of different colored splints for standards has produced a design similar to the Cherokee split cane basket of North Carolina. The

baskets were collected at the Tonawanda reservation but had been made by an Oneida woman.

A good assortment of silver articles was collected. This includes two sets of bracelets or arm bands. These interesting products of Iroquois silversmithing add materially to our already extensive collection.

Peach stone dice. Natural size. Tonawanda Seneca. Collected by A. C. Parker, 1911

A unique acquisition is a set of decorator's tools from the Tonawanda reservation. The set consists of fourteen pieces of which six are swab brushes, six pointed markers (the reverse ends of three being stamps for round spots), three forked for drawing parallel lines, three double forked for making four dots, one horse hoof stamp and one dipping rod for removing splints from dye. The rods are about eight or ten inches long and the swab brushes and pointed sticks taper from the size of a pencil at the large end to an eighth or even a thirty-second of an inch at the smaller end. The outfit is a simple one and was used by a basket maker for decorating baskets, bows and canes. Certain features about the tools suggest that they follow an earlier type and are similar to those which had been in use in earlier times.

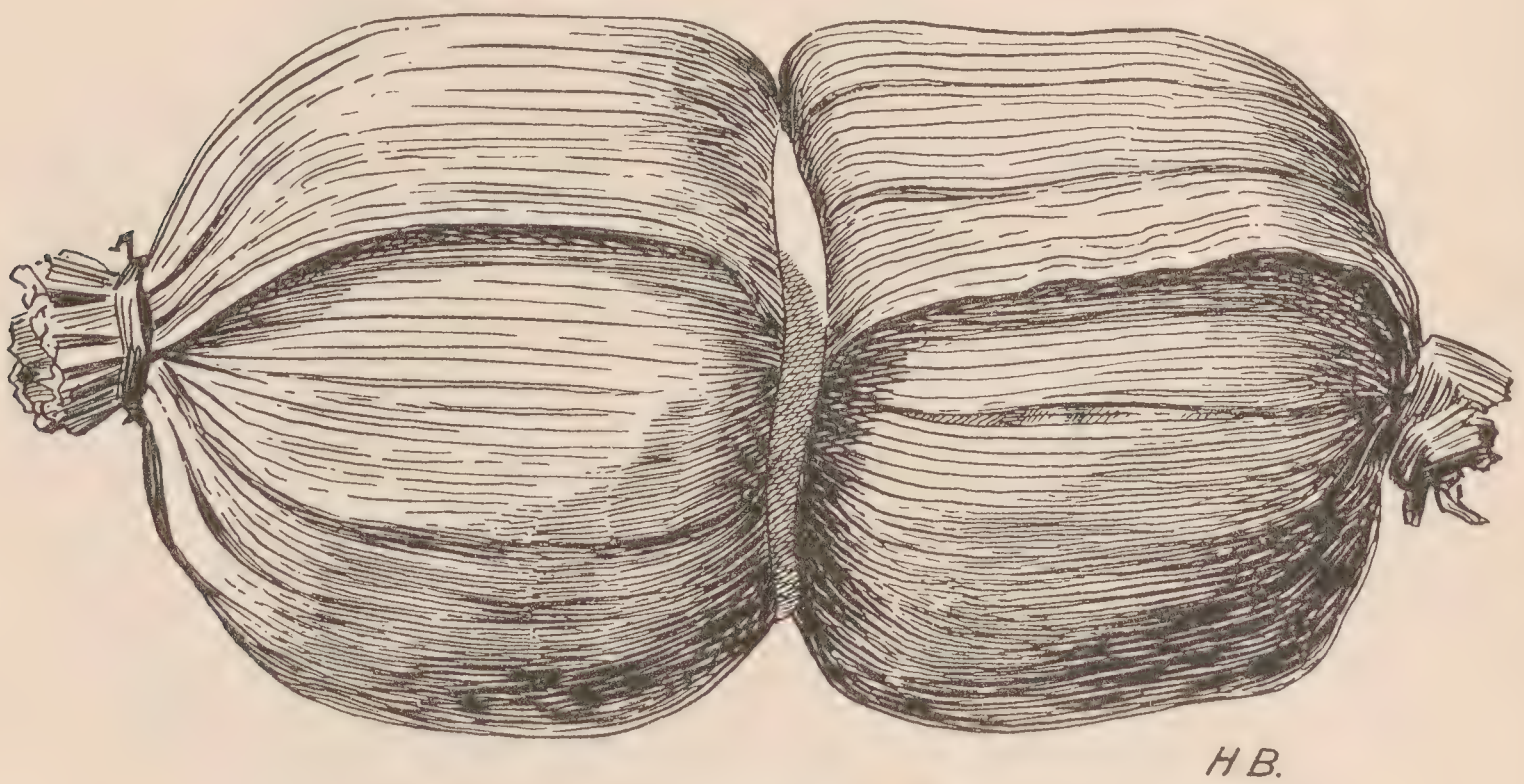
Ethnological studies. During the year just passed the studies of the Iroquois ceremonial rites and cults have been continued, resulting in the addition of new and interesting material.

Of special interest are the many additional notes on the laws of the Five Nations Confederacy. The Archeologist was fortunately able during evenings and holidays to record much of value from the lips of a number of Indians versed in the old-time lore. The manuscripts already on file were annotated in the field and examined critically by various authorities among the Indians themselves.

The Code of Ga-nio-daio was again gone over by Chief So-son-do-wa (Edward Cornplanter) and changes were made at his sug-

gestion. The manuscript in question is Cornplanter's own translation of the "New Religion" of the Six Nations. Cornplanter is one of the five or six "ha-djes-ta-dje" who are familiar with the teachings of the prophet Handsome Lake, or Ga-nio-daio as he is known to the Seneca. The changes made were certain corrections of names and small additions to the text.

The second lengthy manuscript is one compiled by the Archeologist from the various versions of the Iroquois Ga-ya-nes-sha-go-wa, or "Great Binding Law." The Iroquois refer to this as "the constitution" and indeed both Morgan and Hall refer to it by this term.



[Seneca] "wedding" bread. Collected 1910

It purports to be the laws given by Dekanawideh, the Iroquois culture hero, and embraces also a narrative of the lives of both Hai-yent-wa-tha (Hiawatha) and Dekanawideh. Its special interest lies in the fact that it is an attempt of the Iroquois themselves to explain their own social system. It is therefore an invaluable guide to many interesting branches of Iroquois ethnology. Many of the facts contained in this document are familiar to students, but that they formed a part of a definite system of law will perhaps be new. The Iroquois called this code the Gayeneshagowa, or the Immutable Law of the Great Peace. The term Great Peace refers to the Iroquois government.

Originally the Five Nations of Iroquois were similar to all other Indian tribes or bands — independent bodies with similar dialects and similar customs but with no political coherence. Each man and each tribe to itself, was the rule. Often the individual nations warred with one another, and with external enemies pressing them

from all quarters they found themselves in a precarious situation. The very peril in which they lived developed their strategic ability and fostered diplomacy. It likewise produced leaders and finally the great lawgiver who should bring about peace and unity and make the Iroquois the "Indians of Indians," the "Romans of the New World." Hale referred to Hiawatha as the "lawgiver of the Stone age"[1] but Hiawatha himself does not deserve the title.

The Mohawk nation recognizes in Dekanawideh its great culture hero and the founder of its civic system, giving Haiyentwatha (Hiawatha) a second place. Nearly all authorities among the other nations of the five agree in this and attribute to Dekanawideh the establishment of the Great Peace. The prefatory articles of the Great Immutable Law recognize him as such and represent him as saying:

I am Dekanawideh and with the Five Nations' Confederate Lords I plant the Tree of the Great Peace. I plant it in your territory, Adodarhoh and the Onondaga Nation, in the territory of you who are Fire Keepers.

I name the tree the Tree of the Great Long Leaves. Under the shade of this Tree of the Great Peace we spread the soft white feathery down of the globe thistle as seats for you, Adodarhoh and your cousin lords. . . . There shall you sit and watch the Council Fire of the Confederacy of the Five Nations. . . .

Roots have spread out from the Tree of the Great Peace . . . and the name of these roots is the Great White Roots of Peace. If any man of any nation outside of the Five Nations shall show a desire to obey the laws of the Great Peace . . . they may trace the roots to their source . . . and they shall be welcomed to take shelter beneath the Tree of the Long Leaves.

The Smoke of the Confederate Council Fire shall ever ascend and shall pierce the sky so that all nations may discover the central Council Fire of the Great Peace.

I, Dekanawideh, and the Confederate Lords now uproot the tallest pine tree and into the cavity thereby made we cast all weapons of war. Into the depths of the earth, down into the deep underearth currents of water flowing into unknown regions, we cast all weapons of strife. We bury them from sight forever and plant again the tree. Thus shall the Great Peace be established and hostilities shall no longer be known between the Five Nations but only peace to a united people.

As one gets further into the unique document the method by which universal peace is to be established is revealed. All nations were to sit beneath the Peace Tree and acknowledge the imperial regency

[1] Proc. Am. As. Adv. Sci., vol. 30, p. 324. 1881.

of the Five Nations' Council. To the Five Nations this seemed a very simple thing for they called themselves Ongweoweh, *Original Men,* a term that implied their racial superiority. Thus to them it seemed quite natural that other nations should acknowledge their right to rule. They never doubted the justness of their claim or saw that it possibly could be disputed. With them it was the basis for universal action. Other nations were inclined to dispute that the Iroquois were inherently superior and naturally rebelled at the idea of submission even though it might be for their own ultimate benefit.

From tribe to tribe, tradition shows,[1] the emissaries of the Great Peace went carrying with them the messages in their wampum strands, and inviting delegates to sit beneath the Peace Tree and "clasp their arms about it" and to discuss the advantages of an alliance.

The political success of the Iroquois as a result of their system gave them phenomenal strength and likewise excited widespread jealousy. Thus the Iroquois found themselves plunged in a war for existence and without friends to call upon.

How a government calling itself the Great Peace provided for war is shown in the part of the Great Immutable Law called "Skanawatih's Laws of Peace and War." Extracts from these laws follow:

When the proposition to establish the Great Peace is made to a foreign nation it shall be done in mutual council. The nation is to be persuaded by reason and urged to come into the Great Peace. If the Five Nations fail . . . after a third council . . . the War Captain of the Five Nations shall address the head chief of the rebellious nation and request him three times to accept the Great Peace. If refusal steadfastly follows the War Captain shall let a bunch of white lake shells fall from his outstretched hand and shall bound quickly forward and club the offending chief to death. War shall thereby be declared and the War Captain shall have his men at his back to support him in any emergency. War shall continue until won by the Five Nations. . . . Then shall the Five Nations seek to establish the Great Peace by a conquest of the rebellious nation.

When peace shall have been established by the termination of the war . . . then the War Captain shall cause all weapons of war to be taken from the nation. Then shall the Great Peace be established and the nation shall observe all the rules of the Great Peace for all time to come.

Whenever a foreign nation is conquered or has by their own free

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[1] See for example The Passamaquoddy Wampum Records by J. D. Prince, page 483, Proc. Am. Philos, Soc., vol. 36.

will accepted the Great Peace their own system of internal government may continue so far as is consistent but they must cease all strife with other nations.

In this manner and under these provisions and others every rebellious tribe or nation, almost without exception, was either exterminated or absorbed. The Erie, the Neutral, the Huron, the Andaste and other cognate tribes of the Iroquoian stock were broken up and the scattered bands of survivors settled in the numerous Iroquois towns to forget in time their birth nation and to be known forever after only as Iroquois. The law read, "henceforth let no one so adopted mention the name of their birth nation. To do so will hasten the end of the Great Peace." The Lenni Lenape or Delaware, the Nanticoke, the broken bands of the Minsi and the Shawne, the Brotherton and other Algonquian tribes yielded to the armed persuasions to accept the Great Peace; likewise did the Tutelo and Catawba of the eastern Siouan stock and the Choctaw of the Muskoghean yield and to that action is due the fact that they have descendants today.

The Iroquois policy of adopting captives led to the mixture of widely scattered stocks. The Iroquois therefore became an ethnic group of composite elements. Thus from the ideas of universal peace and brotherhood grew universal intermarriage, modified of course by clan laws.

According to the Great Immutable Law the Iroquois Confederate Council was to consist of fifty Rodiyaner (civil chiefs) and was to be divided into three bodies, namely, the Older Brothers, the Mohawk and the Seneca; the Younger Brothers, the Cayuga and the Oneida, and the Fire Keepers, the Onondaga. Each brotherhood debated a question separately and reported to the Fire Keepers. In case of disagreement in opinion the Fire Keepers referred the matter back and ordered a unanimous report. If the two brotherhoods still disagreed the Fire Keepers had the casting vote. If, however, the brotherhoods agreed and their decision was not in accord with the wishes of the Fire Keepers the Fire Keepers could only confirm the decision for absolute unanimity was the law and required for the passage of any question. Provisions to speedily break any deadlock were provided. All the work of the council was done without an executive head, save a temporary speaker appointed by acclamation. Adodarhoh in spite of his high title was only the moderator of the Fire Keepers.

These "Lords" or civil chiefs were nominated by certain noble-

women in whose families the titles were hereditary and the nominations were confirmed by popular councils both of men and of women and finally by the Confederate Council. Women thus had great power for not only could they nominate their rulers but also depose them for incompetency in office. Here, then, we find the right of popular nomination, the right of recall and of woman suffrage, all flourishing in the old America of the Red Man and centuries before it became the clamor of the new America of the white invader. Who now shall call Indians and Iroquois savages!

Not only were there popular councils to check an over-ambitious government but both the men and the women had in their "War Chief" a sort of aboriginal public service commissioner who had authority to voice their will before the Council. Men of worth who had won their way into the hearts of the people were elected Pine Tree chiefs with voice but no vote in the governing body. The rights of every man were provided for and all things done for the promotion of the Great Peace.

Among the interesting things in this Iroquois constitution are the provisions for the official symbols. Many of these symbols, such as the point within a circle, the bundle of arrows, the watchful eagle, are described in detail. The fifteenth string in the Tree of the Long Leaves section, for example, reads:

"Five arrows shall be bound together very strongly and each arrow shall represent one nation. As the five arrows are strongly bound, this shall symbolize the union of the nations . . ."

This reference to the arrows bound together was quoted by King Hendrick in 1755 in his talk with Sir William Johnson.

Perhaps a more striking paragraph to students of Indian history will be the reference to a certain wampum belt:

"A broad, dark belt of wampum . . . having a white heart in the center on either side of which are two white squares all connected with the heart by white rows shall be the emblem of the unity of the Five Nations. The white heart in the middle . . . means the Onondaga nation . . . and it also means that the heart of the Five Nations is single in its loyalty to the Great Peace . . ."

This belt is sometimes called the Hiawatha belt and is one of the most valuable Iroquois belts now extant. It is now on exhibition in the Congressional Library.

The Great Peace as a governmental system was an almost ideal one for the stage of culture with which it was designed to cope. I

think it will be found to be the greatest ever devised by barbaric man on any continent. By adhering to it the Five Nations became the dominant native power east of the Mississippi and during colonial times exercised an immense influence in determining the fate of English civilization on the continent. They, as allies of the British, fought for it and destroyed all French hopes for colonization.

The authors of the Great Immutable Law gave the Iroquois two great culture heroes, heroes without equal in American Indian annals. Through the law as a guiding force and through the heroes as ideals the Iroquois have persisted as a people, preserved their national identity and much of their native culture and lore. Today in their various bodies they number more than 16,000 souls.[1] This is a remarkable fact when it is considered that they are entirely surrounded by a dominant culture whose encroachments are persistent and unrelenting in the very nature of things.

The Canadian Iroquois indeed govern themselves by the laws contained in these codes, proving their utility even in modern days.

Fate of the New York State collections in archeology and ethnology in the Capitol fire. In the New York State Capitol conflagration of March 29th the archeological and ethnological collections of the State Museum were almost totally destroyed by fire and water. The collections were installed in vertical wall and square alcove cases about the corridors at the head of the western staircase. The location seemed to insure singular protection from fire, there being nothing inflammable in the vicinity save the molding that held the cases together. The damage seems to have been done by the long sheets of flame that burst through from the large corridor windows of the library bindery on one side and of the Education Department offices on the other. The immense amount of inflammable material there fed the flames once established and the draft caused by the breaking of the heavy plate windows that opened out into the hall about the staircase carried the blast directly against the cases, shattering the glass and exposing the specimens within. The archeological cases suffered most from the breakage brought about by the crumbling of the sandstone ceilings that had been subjected to the intense heat. The falling of the ceilings in great blocks broke the shelves that had so far resisted the fire and spilled the specimens into the water and debris. The continual dropping of masses of cracked rocks from the walls made work of rescuing valuable objects most hazardous. However, despite the choking smoke, the sudden

[1] Southern Workman, Dec. 1911.

blasts of heat, and the falling walls the majority of the more valuable articles yet untouched by the fire were carried to safety.

The ethnological exhibits consisted principally of three large collections; one made by Lewis H. Morgan before 1854 and embracing some 200 objects, the Harriet Maxwell Converse collection of about 350 specimens, and the collection made by the present Archeologist, embracing nearly 200 rare objects, exclusive of silver ornaments. The famous Morgan collection of old Iroquois textiles and decorated fabrics went up in the first blast of flame, and the cases were burned to their bases. Fortunately about 50 Morgan specimens were in the office of the Archeologist for study purposes, and were thus preserved. The Converse collection of silver articles was rescued intact, though nearly a hundred other brooches and one large medal were lost. Many of the less inflammable objects were rescued during the fire and carried out of the danger zone. None of the wampum belts of the Six Nations was injured.

One of the odd features of the calamity was that hardly a single object connected with the ceremonies of the Iroquois totemic cults or the religious rites was injured. The hair of the thirty medicine masks that hung in a line across the westernmost cases was not even singed.

Of the 10,000 articles on exhibition, including about 3500 flints, only 512 have been identified by their catalog numbers. One thousand other articles, more or less impaired by the action of fire and water, will entail a great deal of work to identify.

It is a curious fact that catalog numbers applied directly to the surface of the stone, bone or clay specimens with waterproof ink, withstood the action of fire and water better than the numbers painted on white varnish or on paper labels. Even when the object had been considerably heated the ink number on the surface was still legible. Paper labels proved valueless, especially those with typewritten numbers. Those with numbers written in waterproof ink came through better.[1]

A conflagration of the magnitude of the Capitol fire is not without its lesson. Its occurrence but adds weight to the oft repeated observation that no building is fireproof when it contains inflammable material. Such material, if in sufficient quantity, once burning, will ruin fire proofing material and expose new channels for the sweeping tongues of flame. The heat will crack walls, crumble stone

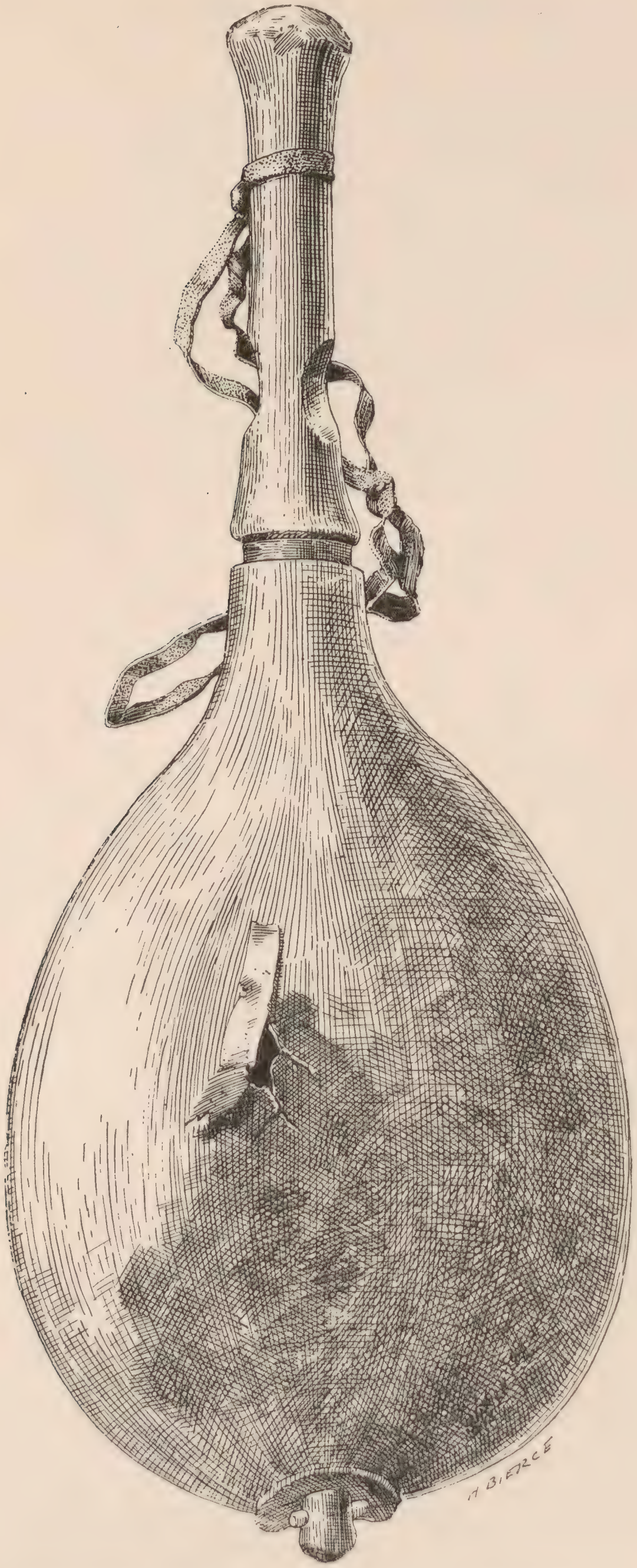
[1]American Anthropologist, January-March, 1911.

Buckskin side pocket decorated with porcupine quills. (Saved from the Capitol fire.) Morgan collection.

Neck pouch decorated with porcupine quills. Mohawk specimen from Morgan collection.

Iroquois beaded garments saved from the Capitol fire.
Mostly Morgan specimens.

The western side of the upper western staircase hall showing how the fire crumbled the stone ceiling and crushed the cases. Some of the wooden cases did not burn. Photo by Coulson and Wendt.



Seneca medicine rattle rescued from the Capitol fire of 1911. A hole was burned in the rattle without destroying the paper label. Converse collection

window sills and precipitate stone and plaster ceilings. Marble wainscotings will chip and fall, tile will loosen and soldered joints will melt.

The selection of the top hall about the western stairway seemed to insure absolute immunity from destruction by fire, but if one were disposed to ask why the Museum authorities of some fifteen years ago did not provide fireproof metal cases and thus doubly insure the valuable collections from damage by fire, a reasonable answer would be that the installation in glass cases with metal frames could in nowise have saved the specimens but only have helped to destroy them. Of the wooden framed cases, only those directly in contact with the root of the flame were burned to their bases. Those exposed to the indirect shafts of flame were not burned, and in some cases the varnish was not even blistered, though the heat was intense enough to melt the glass and expose the contents of the cases. In such of the cases as contained metal supports for shelves, the supports warped and fell and threw the specimens to the lowest level in the case. With the cracking of the plate glass the specimens were thrown in confusion. In the four-sided cases the heavy wooden framework of the case was in no instance burned though in all the glass was cracked by the heat.

A second destructive force was the falling of the heavy sandstone ceiling. Chunk by chunk the stone fell, the pieces varying from three or four cubic inches to great blocks of half a cubic yard. It was the falling of such masses of stone that crushed the cases not otherwise injured. The use of water in the hall to reduce the heat and extinguish the fire was almost as destructive in certain cases. The buckskin clothes in superheated cases were entirely ruined by the play of water upon the glass. The glass cracked and the water entering the cases shrunk the skin articles to one-fourth their size and left them crisp, shriveled objects when the heat had dried them again.

Public interest. Public interest in the work of this section has largely increased. This is due, first, to the natural interest created by a definitely organized archeological and ethnological bureau with a definite policy; and second, to the unusual activities resulting from the use of the funds provided by Mrs F. F. Thompson for carrying out the plan to create a series of ethnological groups. These groups, described elsewhere in this portion of the report, have attracted the attention of many persons interested in history and in anthropology.

Correspondence has grown as the result of the awakened interest

of the public. Inquiries come each day regarding Indian history and anthropology, sometimes many of them. The range of inquiry is broad and covers almost every Indian subject from the interpretation of Indian place-names to opinions as to the legal status of the Indian, from a modest request for a written account of the history of a tribe to a request to outline a scheme for an archeological survey of a country. Many replies to these letters partake of the nature of manuscripts rather than letters and indeed some of the "letters" have been reedited and without further addition to the text worked up into ten or twelve page magazine articles.

With this confidence of the public in our facilities to furnish information on the subjects dealt with by this section of the Museum, better facilities should be provided. Clerical assistance is an imperative necessity.

Another indication of public interest is expressed by the donation of collections and specimens to the Museum. This form of public interest is very gratifying.

Condition of collections. At the close of the fiscal year October 1, 1910–October 1, 1911, a new serial card catalog had been prepared. This work extended through several years, odd moments being employed. The collection number was supplemented with a museum serial number affording better means of identification.

In connection with this work the collections were rechecked from the old lists prepared by Mr A. G. Richmond in 1898. This was an arduous task and one requiring much patience but it resulted not only in improving the condition of the collections but gave the Archeologist a personal familiarity with nearly every specimen and an exact knowledge of the location of every important one. This knowledge became most useful during the fire and during the early hours of the Capitol fire facilitated the rescue of such important relics as were not already destroyed.

The only archeological collection now on exhibition in the Capitol is the collection secured by the Archeologist and his special assistant at Ripley in 1906. This material was exhibited just outside the fire zone and though it was endangered it was carried to a place of safety and not a specimen was injured.

The material now on hand consists of the following lots:

Fire salvage, identified specimens	541
Packed collections, miscellaneous	600
Ripley, Chautauqua co., collection	1050
Mattern collection	2300
Amidon collection	300

Various small collections and exchanges	1200
Expedition collections	1050
Ethnological material	320
Silver articles	159
	7520

Most of this material is in storage but is in good condition. The fire destroyed our best material at the precise point when we had begun to think we had a representative series of collections from the various parts of the State. We are therefore seriously crippled and our extensive plans for a systematic exhibition have received a set-back. Nearly all the material acquired before the appointment of a permanent curator (in 1906) has been wiped out. That which has since been acquired by purchase and donation and through the personal work of the Archeologist in the field has been largely saved. It is a source of some satisfaction to know that his labors have not come to naught.

The Governor Myron H. Clark Iroquois exhibit. Much time has been given to the advancement of this work which involves the preparation of cultural groups of the Six Nations in life-size dimensions. In the course of the last two or three years the life casts necessary for the six groups planned have been gradually assembled and of the large backgrounds measuring 50 by 20 feet which are required for the scenic effect, three have been painted and others are in progress. The greatest care has been taken in the selection of the types of figures from an ethnological point of view. It is not always or often easy to distinguish members of the Six Nations from one another and therefore it has been almost compulsory to take the men, women and children from the reservations regardless of their tribal relations, provided they preserved well their racial physiognomy. The six proposed groups call for about forty figures and of these nearly all have now been made. The making of these life casts is a matter of some delicacy and difficulty inasmuch as the subject must assume and hold just that pose which the figure is to have in the resultant group.

Toward the close of the summer, in view of the accumulated material, it seemed well to attempt the assembling of the first of these groups. The bringing together of the essentials for them had had its difficulties but the crucial test of the success of the undertaking lay in the final assembling and construction of a group with all its belongings in place. This therefore was undertaken and a temporary case erected in the Universalist church which serves as an

The Iroquois exhibit: HUNTER GROUP OF SENECA INDIANS. Scene, Canandaigua Lake; figures, life size

archeological laboratory, wherein the Seneca Hunter group has been thus brought together and carried through to a completion of all its details. In the assembling of this group we had the benefit of an experience which will be of essential service in the construction of the remaining groups and it has required a large amount of time, labor and patience, as well as artistic ingenuity to produce the effect desired, particularly in making the foreground of the group disappear without break or obtrusive interval into the background of the picture. The work in its conclusion appears to be in all regards a success, both artistically and as an almost living expression of this particular phase of Indian activity. This group has not been exposed to public view but has been privately shown to a number of appreciative and intelligent people competent to see any of its shortcomings and appreciate its merits, and it is gratifying to feel that the work has met with quite unqualified approbation.

This Seneca Hunter group represents a camp site on the west side of Canandaigua lake looking across the lake toward the hill Genundewa, or Sacred Hill of the Senecas. The time is the early dawn of a spring day. Looking out from the pine woods which is the location of the camp, the eye catches the shimmer of the dawn upon the waters of the lake and the glow of the coming sun upon the almost cloudless sky beyond the distant hills. The group of figures in the foreground consists of five, the father coming in from an early morning hunt with a fawn on his back, the mother at the skiving log cleaning a deer skin, the daughter on her knees cutting venison into strips, a lad felling a tree in the aboriginal mode of burning the trunk and chopping out the charred matter, and the elder brother, a warrior in full warrior's garb and headtrim. The costumes have been specially designed and adapted to show the clothing of the time, which is supposed to antedate the coming of the white man. The life casts employed are the handiwork of a very skilful sculptor, Mr Caspar Mayer, and have been drawn with such attention to posture and to detail as to retain the surface of the skin in admirable and lifelike perfection.

The completion of this group has satisfactorily demonstrated the possibility of bringing all the groups to a similar successful issue but it has for the present obstructed and impeded the working quarters of the Museum so that the auditorium of the church which has been used some time past as the study of the artist, Mr David C. Lithgow, who has painted the backgrounds, is diminished to about one-half its size and the continuation of the artist's work will be

prosecuted at some disadvantage. It is hoped to complete the cases for these groups in the Education Building early and by so doing enable the removal of the first group to its proper place and with it out of the way opportunity will be afforded to try out the other groups experimentally before setting them up in their final resting places.

I should take this occasion to speak here with very great appreciation of the admirable service rendered by David C. Lithgow, the artist of the background pictures, in the matter of assembling the parts of this group and bringing out the difficult distance effects so essential to the perfection of the assemblage. The work has required not only artistic appreciation but a large degree of mechanical ingenuity and execution.

Not all of the work of the year has been given to the matter of perfecting this group. During the winter months and up into the early spring Mrs Shongo and her daughter, Mrs Maud Shongo Hurd, two Seneca women, were employed in the Archeologist's rooms in embroidering deerskin costumes in quill, moose hair and beadwork for these life casts. The art of working in moose hair and quill is almost extinct and so indeed is that of working all embroidery of the old style. These women were the only ones found who were still familiar with the technic of this handiwork. Great care was taken in the execution of this work to have every design and detail authentic.

The Archeologist in the early summer located the historical sites for subjects of backgrounds; an Oneida village near Nichols pond in the town of Fenner, Madison county, an Oneida stronghold stormed by Champlain in 1615, and the Onondaga capital village in the town of Manlius, Onondaga county. The latter is now known as Indian Hill and overlooks the valley of Limestone creek. Some weeks were consumed here by Mr Lithgow in making the sketches that are to serve as the data for his large paintings. Later in the summer a site was selected for the Cayuga Ceremonial group at Utt's Point.

The selection of additional models from among the Onondagas who were to pose for the various characters in the Onondaga Council group was a matter of some difficulty and when the models were secured they were brought to Albany and very successfully cast by Henri Marchand, and in some cases casts of typical faces have been made by the Archeologist himself.

Materials for the accessories to the groups have been sought for

A life cast of an Onondaga chief made for the Council group of the Hall of Iroquois Ethnology, by Sculptor Henri Marchand.

A corner in the plaster studio. Life casts of two Indian women, a baby and a man are being painted by Sculptor Mayer, for the Hall of Iroquois Ethnology.

Typical Iroquois moose hair decoration on buckskin. From leggings made 1910–11 by Mrs A. Shongo and Mrs M. Shongo-Hurd, Seneca women.

and found, among other things a suitable log cabin for the Cayuga group which was obtained on the Tonawanda reservation and has been shipped to Albany. Every log in this cabin was so numbered that its reconstruction is made easily possible.

At the present time the work of painting the background for the Oneida group is proceeding as rapidly as practicable and it may be said that the materials necessary for all the groups are essentially ready to assemble.

LIST OF ARCHEOLOGICAL SPECIMENS DESTROYED IN THE CAPITOL FIRE, MARCH 29, 1911

Pair of silver bracelets
6 pairs of silver earrings
Silver hatband
Silver bracelets
Belt
Wampum beads
Ladle
Wooden mask
2 bows
Ball bat
Baby frame
Gambling bowl
Dice (of peach stones) for gambling bowl
Seneca corn soup paddle
Indian flute
Iroquois sacred flute
Provision bag — seamless
Corn husk mask
Corn husk dishes (2), Seneca
Corn husk water bottle
Corn husk salt bottle
2 basket meal sifters
Bark sap tub
Bark tray
Box, birch, and moose hair work
2 Indian dolls
Carved stone pipe
Indian sling for hurling stones
Pair of women's beaded cloth leggings
2 pairs women's moccasins
Very old work pouch
Pair Indian buckskin mittens
Mary Jemison's soup ladle
Seneca bark ladle
Very ancient bone spoon
Amulet stone (Seneca)
Kettle
Model of wooden corn mortar and pestle
Ring puzzle
Indian drum
Card containing catlinite ornaments, copper bells and Venetian beads
Shell ornament
13 ceremonial stones
Long canoe-shaped slate stone
Stone ornament
Bird or eagle stone
Slate ball
Bar amulet
Sinew stone
15 clay pipes
7 stone pipes
5 stone gouges
Turtle shell
Bone comb
2 deer antlers
Bone harpoon
3 bone awls
Bone needle
Bone object
Bone mask of human face
Bone carving
15 bone (bird) beads
2 bone fish-hooks
String with various kinds of beads
7 catlinites
1007 beads
8 stone sinkers
Stone gouge

6 stone pestles
Decorated pottery
3 hammer stones
48 spear heads
6 scrapers
7 chert knives
10 leaf-shaped objects of chert
Chert flake with saw edge
4 chert drills
215 shell beads
Game stone
Flint agricultural tool
Stone for smoothing and rounding arrow shafts
Slate ornament
Discoidal or Chunkee stone
3 clay vessels
Red paint
16 stone celts
Stone chisel
Card containing:
- 4 copper arrow points
- 2 iron knife blades
- 1 iron chisel
- 3 copper arrow points
- 1 iron fish-hook
- 1 copper bead
- 1 iron awl
- 5 copper thimbles
- 2 copper bells
- 1 copper bracelet
- 10 copper tubes
- 1 copper disk
- 1 copper ring
- 1 piece graphite

116 arrow points
Chert agricultural implement
Card containing 11 arrow points
Small stone object in form of bean
Deer's antler cut to a beveled edge on end
2 perforated canine teeth
3 stone axes
Stone maul
Stone mortars (2)
Card containing 124 arrow points drills, spear heads, knives and leaf-shaped objects
21 chert gambling pieces
Shell ornaments
4 shell beads
35 bones, taken from feet of wolves, finished for necklace use
2 bones for smoothing purposes
5 bones used in manufacture of arrows
8 bears' teeth used for different purposes
14 bones used for rubbing or smoothing purposes
15 bird bones cut for use as beads
3 bone harpoons for fishing
Bone fish-hook
56 bone objects for different purposes
10 deer horn objects for different purposes
21 bone arrow points
106 bone awls
Human skull with perforations
Esquimaux object made of ivory
44 clay pipes
33 stone pipes
2 bayonets
2 buttons
Part of flint lock gun
29 fragments of decorated pottery
Copper disc
3 clay discs
2 stone objects
2 bird stones
12 stone gouges
Soapstone kettle
Iron tomahawk
String of Indian beads and ornaments
Green serpentine stone axe
11 stones used for sharpening purposes
5 rubbing stones
4 fragments soapstone kettles
Stone fishing sinkers
Grooved stone axe
2 western arrow points
8 stone corn pounders or pestles
8 game stones
5 hammer stones
Ceremonial stones (13)
2 stone tubes
2 stone knives
Copper spear head

4 clay vessels
3 chert drills
51 arrow points
9 chert leaf-shaped implements
3 scrapers
50 spear heads
5 heads of various animals in clay
24 clay pipe bowls
3 clay pipe fragments
2 stone axes
66 stone celts
Stone mortar
Indian war club
Iron tomahawk and pipe combined
23 clay vessels
3 copper kettles
2 carved bone images of human beings
7 bone tools
3 bone arrow points
Stone celt
3 stones for sharpening tools
Stone sinker
5 stone spear heads
8687 Venetian glass beads
3 stone pipes
23 clay pipes
10 portions of turtle shell
6 portions of wooden ladles
3 cloth fragments
Strip of buckskin clasped with copper fasteners
Necklace
Copper tube
String of 140 wampum beads 20 inches long
String of 378 wampum beads 54 inches long
String of 392 wampum beads 56 inches long
String of 700 wampum beads 56 inches long
4 strings of beads
Necklace composed of the teeth of the bear and wolf (62 in number)
String of 23 teeth of the elk
String of 11 natural shells
String of 256 copper beads
2 grinding stones
8 iron trade axes
Copper kettle containing 109 arrow points
2 chert knives
Leaf-shaped implements (2)
Stone pipe
3 clay pipes
Bone comb
Necklace (very fine specimen)
3 necklaces consisting of shell ornaments
147 miscellaneous ornaments
Wooden spoon
Wooden cup
Bone spoon
Clay vessel
Pair of copper bracelets
8 strings of beads (various kinds)
Brass kettle containing 68 various objects
15 cards containg 111 Indian relics of various kinds
Land tortoise shell with perforations
29 gambling devices
Bone punch
Bone handle
3 chert scrapers
5 leaf-shaped objects
2 spear heads
12 arrow points
2 chert drills
Ceremonial stone
5 stone celts
Grooved axe
2 gouges
8 sharpening stones
4 stone corn pounders
7 game stones
2 iron axes
Iron hoe
Fragments of pottery
8 strings of beads of various kinds
6 clay pipes
58 clay pipe fragments
Lead pipe
Copper pipe
2 stone pipes
2 stone pipe fragments
Bone comb
2 clay vessels
Clay disk

13 clay pottery fragments
72 bone tools (fragments)
3 soapstones (decorated)
7 soapstones (plain)
4 ceremonial stones
79 stone knives
Iron trade axe
3 chert drills
5 game flints
Long gun barrel
Jasper scrapers (7)
5 quartz scrapers
11 copper beads
2 copper arrow points
Piece of decorated copper
22 celts
4 stone mullers
3 stone hammers
2 sharpening stones
3 sinew stones
Chert spade
11 stone plummets
4 stones used for agricultural purposes
28 stones used for various purposes
25 leaf-shaped implements
392 spear heads and arrow points
126 chert drills
23 large chert objects
Rubbing stone
615 chert scrapers
Copper ring
Brass kettles
91 flint points
Shell gouge
Shell chisel
2 pipes (red stone)
Tomahawk
Shell ornaments
10 bone implements
3 bone ornaments
Totem pipe
2 pipes
Fish hook of bone
3 sink stones
Wampum beads
2 ceremonial stones
2 celts
Pottery fragments
Fish hook and line

Clay pipes (4)
Steatite pipe
Stone pipe
Bird stone
Copper spear head
10 spear heads
Ceremonial object
Indian skull
Tomahawk
2 stone chisels
17 stone knives
Scraper
6 gouges
3 sinkers
11 celts
11 grooved axes
2 stone hammers
8 drills or perforations
19 spear heads or knives
26 arrow points
6 pestles
2 ceremonial objects
Steatite pipe
3 celts
Hammer and sinker combined
Game stone
Knives or spears (12)
55 spear heads
132 arrow points
5 bunt scrapers
Copper spear head
6 stone pestles
8 celts
Hammer stone
Grooved axe
Stone mortar
Leaf-shaped chert implements (7)
4 drills
Iron trade-axe
38 hammer stones
19 celts
13 scrapers
70 clay pipe fragments
3 clay disks
8 stone disks
11 beads
8 bone awls
3 bone needles
98 bone tools
Bone pottery marker

Human faces molded in clay (2)
8 shell ornaments
296 bones and teeth for ornamental and useful purposes
235 pottery sherds (decorated)
13 pottery sherds (plain)
2 stone ornaments
2 mortars
Sharpening stone
2 iron axes
1 stone pipe
16 beads
10 arrow points
Game stone
31 arrow points
8 gun flints
Copper ornament
48 arrow points
Red slate pendant
Decorated clay pottery fragments (35)
7 plain clay pottery fragments
2 celts (fragments)
9 clay pipes (fragments)
5 celts
3 hammer stones
Animals' bones and teeth (27)
Sandstone pipe
3 bone awls
Bone arrow
2 game stones
4 shells
Pottery vessel
5 bone tools
Scraper
5 spear heads (chert)
Spear head (copper)
31 arrow points
13 arrow points (copper)
Arrow point (bone)
2 knives
2 drills
6 gun flints
Sinker
4 leaf-shaped pieces of chert for various purposes
2 iron knives
Smoothing stones
81 pottery sherds (decorated)
68 pottery sherds (plain)
Pottery marker
133 animal bones
25 shells
3 bone tools
Harpoon (bone)
Flaking tool
Corn pounder
Rubbing stone
4 scrapers
5 pottery pipes (fragments)
Copper kettle (fragment)
2 bone awls
Hammer stone
3 stone mortars
2 stone pestles
12 stone chisels
Stone gouge
Spear head (chert)
Indian knife (chert)
4 tomahawks
Brass kettle
Gun lock and rifle barrel
2 war clubs
Moccasin needle
Stone tube
Stone amulet
Indian necklace of teeth
Earthen basin
Headdress (Seneca)
Calumet
Leaden cross
Stone skull cracker
La Crosse sticks (2)
2 Indian bows
6 feathered arrows
2 snow snakes
Bark tray or platter
2 splint baskets
Medicine pouch
String of stone beads
Bark canoe (model)
4 paddles
Cigar case
2 card receivers
Watch case
2 clay pipes
3 pipes (not complete)
16 arrow heads
Arrow head (copper)
Knee rattle

Arm bands (1 pair)
Wrist bands (1 pair)
Knee bands (1 pair)
Indian belts (3 varieties)
Moccasins (2 pairs)
2 kilts or skirts
2 pairs leggings
Necklace
Pin cushions (3 varieties)
Work bags (5 varieties)
Pocketbooks (6 varieties)
Breech cloth
Needle book
Baby frame
3 bark trays
2 hominy blades
Bowl for game, with peachstones
Deer buttons for an Indian game
Javelins for an Indian game
4 tobacco pouches
Ball bat for an Indian game
Pipe
6 Indian bows
2 burthen-straps
2 skeins
2 husk salt-bottles
Air gun
Bow and wheel for striking fire
2 basket sieves
Open-work basket
Toilet basket
Headdress
Sheaf for carrying arrows
Satchel
Work bag
2 pin cushions
Kilt
Deerskin shoulder-belt
3 moccasins
Shot pouch
3 hominy blades
Bread turner
4 wooden ladles
Wooden spoon
6 bark trays
Bark sap-tub
Glass beads
2 canes
Belt and knife
Horn rattle
War club
2 Indian flutes
Indian bow
Ball bat
Feathered arrows (18 specimens in sheath)
Tobacco pouch
Moosehair and bark burthen-strap
Burthen-straps (6)
Grass shoulder ornament
2 bark ropes
Finger-catcher
Basket sieve
Covered basket
Hominy blade
Skirt
Leggings (2 pairs)
Broadcloth blanket
Snow-boat
Bark canoe
Museum collection of flints
Museum collection of pottery
Museum collection of polished stone articles

VII

PUBLICATIONS

A list of the scientific publications issued during the year 1910–11, with those now in press and treatises ready for printing, is attached hereto. The publications issued cover the whole range of our scientific activities. They embrace 1042 pages of text, 151 plates and 5 maps.

The labor of preparing this matter, verifying, editing and correcting is onerous and exacting. Taken altogether, it excellently indicates the activity and diligence of the staff of this division.

ANNUAL REPORT

1 Seventh Report of the Director, State Geologist and Paleontologist for the fiscal year ending September 30, 1910. 280p. 42pl.

Contents:

Introduction
I Condition of the scientific collections
II Report on the geological survey
Areal geology
Surficial geology
Industrial geology
Seismological station
Mineralogy
Paleontology
III Report of the State Botanist
IV Report of the State Entomologist
V Report on the zoology section
VI Report on the archeology section
Ethnology
Archeology
The Mary Jemison monument
VII Publications
VIII Staff
IX Accessions
X The New York State Museum Association
Comparative Sketch of the Precambric Geology of Sweden and New York. J. F. KEMP
Notes on the Geology of the Swedish Magnetites. D. H. NEWLAND
Notes on the Geology of the Gulf of St Lawrence. J. M. CLARKE
The Carbonic Fauna of the Magdalen Islands. J. W. BEEDE
Exfoliation Domes in Warren County, New York. W. J. MILLER
Studies on Some Pelmatozoa of the Chazy Epoch. G. H. HUDSON
Index

BULLETINS

Geology

2 No. 146 Geologic Features and Problems of the New York City (Catskill) Aqueduct. By Charles P. Berkey. 286p. 38pl. maps.

Contents:

Introduction and acknowledgment
I General features
Ch. 1 Catskill water supply project
2 Problems encountered in the project
3 Relative values of different sources of information and stages of development
4 General geology of the region
II Geologic problems of the aqueduct
Introduction
Ch. 1 General position of aqueduct line
2 Hudson river canyon
3 Geological conditions affecting the Hudson river crossing
4 Geological features involved in selection of site for the Ashokan dam
5 Character and quality of the bluestone for structural purposes

Ch. 6 The Rondout valley section
7 The Wallkill valley section
8 Ancient Moodna valley
9 Rock condition of Foundry brook
10 Geology of Sprout brook
11 Structure of Peekskill creek valley
12 Croton lake crossing
13 Geology of the Kensico dam site
14 Stone of the Kensico quarries
15 The Bryn Mawr siphon
16 A study of shaft 13 and vicinity on the New Croton aqueduct
17 Geological conditions affecting the location of delivery conduits in New York city
18 Areal and structural geology south of 59th street
19 Special exploration zones
20 The general question of postglacial faulting
Index

3 No. 148 Geology of the Poughkeepsie Quadrangle. By C. E. Gordon. 122p. 26pl. 1 map.

Contents:

Introduction
Location and other general features of the quadrangle
Topography
Drainage
General geology
Previous geologic work
Stratigraphical table
The Precambric gneisses
The Hortontown basic eruptive and associated metomorphic rocks
The basal quartzite (Poughquag)
The Wappinger (Barnegate) limestone
The Wappinger creek belt
The Fishkill limestone
The "Hudson River" slate group
Preglacial history of the drainage
Glacial geology
Retreat of the ice sheet
Postglacial erosion
The present depression
Other drainage features and adjustments
Land forms
Economic geology
Bibliography
Index

4 No. 151 The Mining and Quarry Industry of New York. By D. H. Newland. 82p.

Contents:

Introduction
Mineral production of New York
Cement
Clay
Production of clay materials
Manufacture of building brick
Other clay materials
Pottery
Crude clay
Emery
Feldspar
Garnet
Graphite
Gypsum
Iron ore
Millstones
Mineral waters

Natural gas
Petroleum
Pyrite
Salt
Sand and gravel
Slate
Stone
  Production of stone
Stone (*continued*)
  Granite
  Limestone
  Marble
  Sandstone
  Trap
Talc
Index

5 No. 152 Geology of the Honeoye-Wayland Quadrangles. By D. D. Luther. 30p. 1 map.

Contents:

Formations in ascending order
  Ontaric or Siluric
    Camillus shale
    Bertie (and Cobleskill ?) waterlime
  Devonic
    Oriskany sandstone
    Onondaga limestone
    Marcellus black shale
    Stafford limestone
    Cardiff shale
    Skaneateles shale
    Ludlowville shale
    Tichenor limestone
    Moscow shale
    Pyrite layer in horizon of Tully limestone
Devonic (*continued*)
    Genesee black shale
    Genundewa limestone
    West River dark shale
    Middlesex black shale
    Cashaqua shale
    Rhinestreet black shale
    Hatch shale and flags
    Grimes sandstone
    Gardeau flags and shales
    Nunda sandstone
    Wiscoy beds
    Chemung sandstone and shale
    Dip
Index

Entomology

6 No. 147 Report of the State Entomologist for the fiscal year ending September 30, 1910. 182p. 35pl.

Contents:

Introduction
Injurious insects
  Codling moth
  Juniper webworm
  Large aphid spruce gall
  Ash psylla
Notes for the year
  Fruit insects
  Garden and grain insects
  Shade tree pests
Notes for the year (*continued*)
  Forest tree insects
Miscellaneous
Publications of the Entomologist
Additions to collections
Appendix
  Miastor americana Felt, an account of pedogenesis
Explanation of plates
Index

Botany

7 No. 150 Report of the State Botanist for the fiscal year ending September 30, 1910. 100p. 10 pl.

Contents:

Introduction
Plants added to the herbarium
Contributors and their contributions
Species not before reported
Remarks and observations
New species and varieties of extralimital fungi
Edible fungi
Cranberry and Averyville marshes
New York species of Hypholoma
New York species of Psathyra
Explanation of plates
Index

GEOLOGIC MAPS

8 Poughkeepsie quadrangle
9 Honeoye-Wayland quadrangles

In press

MEMOIRS

10 Birds of New York, volume 2
11 Eurypterida of New York

BULLETINS

Geology

12 Glacial Geology of the Schenectady Quadrangle
13 Geology of the Broadalbin Quadrangle
14 Glacial Waters in the Black and Mohawk Valleys
15 The Mineral Springs at Saratoga

ENTOMOLOGY

16 Report of the State Entomologist for the fiscal year ending September 30, 1911

Botany

17 Report of the State Botanist for the fiscal year ending September 30, 1911

VIII

STAFF OF THE SCIENCE DIVISION AND STATE MUSEUM

The members of the staff, permanent and temporary, of this division as at present constituted are:

ADMINISTRATION

John M. Clarke, Director
Jacob Van Deloo, Director's clerk
Paul E. Reynolds, Stenographer

GEOLOGY AND PALEONTOLOGY

John M. Clarke, State Geologist and Paleontologist
David H. Newland, Assistant State Geologist
Rudolf Ruedemann, Assistant State Paleontologist
C. A. Hartnagel, Assistant in geology
Robert W. Jones, Assistant in economic geology
D. Dana Luther, Field Geologist
Herbert P. Whitlock, Mineralogist
George S. Barkentin, Draftsman
H. C. Wardell, Preparator
Michael T. Sammon, Stenographer
Martin Sheehy, Machinist
Joseph Bylancik, Page

Temporary Experts

Areal geology

Prof. H. P. Cushing, Adelbert College
Prof. J. F. Kemp, Columbia University
Dr C. P. Berkey, Columbia University
Dr Arthur Hollick, Bronx Garden
G. H. Hudson, Plattsburg State Normal School
Prof. W. J. Miller, Hamilton College
Dr W. O. Crosby, Massachusetts Institute of Technology
Dr H. B. Kümmel, Trenton, N. J.
Burton W. Clark, Washington, D. C.

Geographic geology

Prof. Herman L. Fairchild, Rochester University
Prof. Albert P. Brigham, Colgate University

Paleontology

Edwin Kirk, Washington, D. C.

BOTANY

Charles H. Peck, State Botanist
Stewart H. Burnham, Assistant

ENTOMOLOGY

Ephraim P. Felt, State Entomologist
D. B. Young, Assistant State Entomologist
Fanny T. Hartman, Assistant
Anna M. Tolhurst, Stenographer
J. Shafer Bartlett, Clerk

ZOOLOGY

Willard G. Van Name, Zoologist
Arthur Paladin, Taxidermist

Temporary Experts

Prof. E. Howard Eaton, Canandaigua
Dr H. A. Pilsbry, Philadelphia

ARCHEOLOGY

Arthur C. Parker, Archeologist

Temporary assistant

E. R. Burmaster, Irving

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ACCESSIONS

ECONOMIC GEOLOGY

Collection

Newland, D. H. Albany
Building stones, rough and polished, from Adirondacks..... 20
Talc from St Lawrence county..... 5
Pyrite ore from Gouverneur, N. Y..... 2
Feldspar from New York quarries..... 12
Jones, R. W. Albany
Building stones, rough and polished, from southeastern New York. 40
Kaolin from Shenandoah, N. Y..... 5

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PALEONTOLOGY

Donation

Allardyce, Mrs W. L. Falkland Islands
Fossils from Falkland Islands..... 90
Cole, Rev. Thomas. Saugerties, N. Y.
Number of starfish on large slab..... 1
Foerste, Dr A. F. Dayton, Ohio
Clitambonites diversus-rogersensis Foerste..... 11

Hudson, Prof. G. H. Plattsburg, N. Y.
Asaphus marginalis from Valcour Island..... 2
Jones, R. W. Albany
Dictyonema crassum Girty. Cotype..... 1
Kirk, Edwin. Washington, D. C.
Fossils from Black River limestone, Kirkfield, Ontario, Canada.... 100
Ormiston, Prof. William T. Constantinople, Turkey
Devonic fossils from Roumeli-Hissar, Turkey..... 115

Exchange

van Ingen, Prof. Gilbert. Princeton, N. J.
Eurypterids from base of Salina at Farmers Mills, Oneida co., N. Y..... 8

Purchase

Dean, R. C. Dalhousie, N. B.
Devonic fishes from Migouasha..... 10
Krantz, Dr F. Bonn, Germany
Foreign trilobites..... 7
Plourde, Anthony. Migouasha West, P. Q.
Devonic fishes from Migouasha, P. Q., Canada..... 137

Collection

Clarke, John M.
Devonic fossils from near New Richmond, P. Q..... 6
Siluric fossils from New Richmond, P. Q..... 40
Lower Devonic limestones..... 10
Pleistocene shells from elevated beaches, New Richmond, P. Q., Canada 50
Mya truncata
Macoma sabulosa
M. balthica
Serripes groenlandicus
Chrysodomus despectus
Devonic coal, Cape Haldimand, Gaspé Bay, P. Q., Canada..... 1
Hartnagel, C. A.
Eurypterids from Herkimer county..... 570
Ruedemann, R.
Graptolites and eurypterids from Normanskill shale at Catskill.... 250
Fossils from lower Siluric shales and limestones of Schuylerville sheet 200
Wardell, H. C.
Fossils from Canajoharie (Trenton) shale near Watervliet..... 70
Starfishes from Hamilton formation in Ulster co..... 200

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MINERALOGY

Donation

Jones, R. W. Albany
Native copper and cuprite, Box Elder co., Utah 1
Pyrite (crystal) " " 1
Malachite and azurite " " 1
Cuprite and chysocolla " " 1
Aurichalcite on azurite " " 1
Malachite and chrysocolla " " 1
Pyrite, Boulder co., Col 1
Sanford, Gen. Denver, Col.
Pyrargyrite, Gunniston co., Col 1
Sylvanite and fluorite, Cripple Creek, Col 1
Sylvanite, Cripple Creek, Col 2
Quartz (amethyst), Colorado 1
Hough, R. B. Lowville, N. Y.
Sphalerite in quartz, Lyonsdale, Lewis co 1
Quartz, Lyonsdale, Lewis co 5
Hartnagel, C. A. Albany, N. Y.
Calcite, near Three Forks, Mont 4
Stow, J. E. Saratoga, N. Y.
Marcasite and sphalerite, Elizabethtown, N. Y 1
Malachite in limonite, Indian Lake, N. Y 1
Tourmalin in pegmatite, Greenfield, N. Y 1
Quartz in limestone, Saratoga, N. Y 1
Malachite, azurite, chalcocite, Adirondacks (?) 5
Van Loon, E. S. Albany, N. Y.
Aragonite in conglomerate, Albany, N. Y 3
Gavit, J. Albany, N. Y.
Quartz (crystal), Wemple, N. Y 1
Herrick, D. W. Albany, N. Y.
Quartz, New Baltimore, N. Y 1

Exchange

Law, E. S. Schenectady, N. Y.
Quartz (crystals), Amsterdam, N. Y 15
Goodwin, H. R. Philadelphia, Pa.
Barite on dolomite, Frizington, England 1
Jandorf, M. L. York, Pa.
Cerargyrite, embolite and iodyrite, Tonopah, Nevada 1
Pyrite in shale, York, Pa 5
Chrysocolla and chalcocite, York, Pa 5
Magnetite, Barts, Berks co., Pa 3
Rutilated quartz, York, Pa 4

Purchase

Law, E. S. Schenectady, N. Y.
Quartz on chalcedony, Amsterdam, N. Y 4
Quartz (crystals), Amsterdam, N. Y 3

Collection

Assistant State Geologist and R. W. Jones

Titanite and fluorite, Fine, N. Y..... 5

Mineralogist and C. A. Hartnagel

Beryl (large crystals), Batchellerville, N. Y..... 10
Beryl (crystals), Batchellerville, N. Y..... 5
Beryl, in microcline and quartz, Batchellerville, N. Y..... 11
Muscovite (cleavage sheets showing inclusions), Batchellerville, N. Y..... 3
Muscovite (large crystals), Batchellerville, N. Y..... 8
Muscovite, in microline and quartz, Batchellerville, N. Y..... 8
Quartz (rose), Batchellerville, N. Y..... 7
Pyroxene and muscovite in pegmatite, Batchellerville, N. Y..... 1
Fluorite and quartz, Batchellerville, N. Y..... 1
Microcline (crystal), Batchellerville, N. Y..... 1

Mineralogist

Aragonite in conglomerate, Albany, N. Y..... 14
Quartz (chalcedony), Saratoga, N. Y..... 6
Quartz (flint), Saratoga, N. Y..... 3
Garnet and graphite in serpentine, Saratoga, N. Y..... 4

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ENTOMOLOGY

Donation

Hymenoptera

Miller, Mrs M. S. Boonville. Thalessa atrata Fabr., black long sting, July 6

Baker, A. N. Bellport. Rhodites bicolor Harr., spiny rose gall, old galls on rose, June 19

Douglass, J. A. Oriskany Falls. Cynips? prinoides Beutm., gall, September 14

Wallace, Sterling. New York City. Tremex columba Linn., pigeon Tremex, adults on hickory, September 12

Sharpe, H. C. Schenectady. Caliroa cerasi Linn., cherry and pear slug, eggs on cherry, June 3

Livingston, J. H. Tivoli. Kaliofenusa ulmi Sund., elm leaf miner, larvae on elm, May 30

Howe, Madam. Kenwood. Same as preceding, May 31

Graff, Stephen. Johnstown. Same as preceding, June 16

Helme, F. C. Chester. Trichiocampus viminalis Fallen, poplar sawfly, larvae on poplar, August 13

Harris, W. H. Greenfield Center. Same as preceding, August 30

Barron, Leonard. Garden City. Abia inflata Nort., larvae on Lonicera, June 8

State Department of Agriculture. Trichiosoma tibialis Steph., cocoon and pupa on Crataegus from Holland, April 10

Coleoptera

Hyle, Fisher. Germantown. Eccoptogaster rugulosus Ratz., adult, August 8

Cushman, R. L. Yonkers. E. quadrispinosus Say, adult on hickory, August 13

Brisbin, C. E. Schuylerville. Gymnetron teter Fabr., adult, June 21

Sargent, Miss G. W. Lenox, Mass. Rhynchites bicolor Fabr., rose curculio, adults and work, October 26

Nards, R. S. Slingerlands. Pomphopoea sayi Lec., Say's blister beetle, adults, May 31

Bowen, Smith. Hartford. Same as preceding, May 31

Hart, Matthew. Castleton. Same as preceding, on locust blossoms, June 5

Winne, C. M. Castleton. Same as preceding, adult, June 8

DeGarmo, A. C. Schuylerville. Same as preceding, June 8

Jansen, Frank. Fonda. Same as preceding, June 14

Ward, J. G. Cambridge. Same as preceding, June 16

Ward, Arthur. Philmont. Same as preceding, on cherry, June 20

Brisbin, C. E. Schuylerville. Same as preceding, adult, June 21

Fairman, C. E. Lyndonville. Meloe angusticollis Say, oil beetle, adult, September 15

Bush, Miss E. Albany. Tribolium confusum Duv., confused flour beetle, adults, November 29

Frost & Bartlett Co. Stamford, Conn. Chalepus dorsalis Thunb., locust leaf miner, adults on locust, August 30. Also C. nervosa Panz., adult on locust, August 30

Rose, J. F. South Byron. Systena taeniata Say var. blanda Melsh., adult on bean, June 29

Wicks, F. B. Ticonderoga. Galerucella luteola Müll., elm leaf beetle, larvae, June 28

Satterlee, H. L. Highland Falls. Same as preceding, larvae, pupae and adults on elm, July 6

Bell, Miss S. L. Amsterdam. Same as preceding, eggs on elm, July 21

Wood, Miss F. A. Poughkeepsie. Same as preceding, adult on elm, August 7

Bloodgood Nurseries. Flushing. Through State Department of Agriculture. Melasoma scripta Fabr., lined cottonwood beetle, egg, larvae and adult on poplar, August 18

Hicks, J. J. Jericho. Crioceris asparagi Linn., asparagus beetle, adults on asparagus, May 19. Also C. duodecimpunctata Linn., 12-spotted asparagus beetle, adults on asparagus, May 19

Shutts, W. H. Claverack. Saperda candida Fabr., roundheaded appletree borer, adults on apple, May 25

Onderdonk, A. F. Webster Groves, Mo. Plectrodera scalator Fabr., banded poplar borer, adult, July 26

Flanders, C. Y. Tribes Hill. Monohammus confusor Kirby, pine sawyer, larvae on pine, March 14

Wadsworth, Leland. Troy. Same as preceding, adult, June 5
Pickering, F. B. Ballston Spa. Same as preceding, June 6
Feeney, James. Meadowdale. Phymatodes variabilis Fabr., variable oak borer, adults reared from oak, June 5
Huxley, F. T. Amsterdam. Desmocerus palliatus Forst., cloaked knotty horn, adults on elder, June 2
State Department of Agriculture. Mount Vernon. Neoclytus erythrocephalus Fabr., adult on maple, June 16
Baldwin, E. A. Schenectady. Euphoria inda Linn., bumble flower beetle, adult, May 30
Brisbin, C. E. Schuylerville. Anomala lucicola Fabr., light loving grapevine beetle, adult, June 21. Also Serica sericea Ill., adult, June 21
Draper, R. C. Rochester. Through State Department of Agriculture. Hoplia trifasciata Say, injuring pear blossoms, from Greece, May 16
Scudder, J. B. Coxsackie. Canthon laevis Dru., tumble bug or dung beetle, adult and dung ball, May 27
Gibbes, R. H. Schenectady. Amphicerus bicaudatus Say, apple twig borer, work on cherry, June 23
Joutel, L. H. New York City. Thelydrias contractus Mots., adult, pupal and larval skins, June 20
Clapp, S. K. Brown Station. Through State Conservation Commission, Agrilus bilineatus Web., two-lined chestnut borer, larvae on chestnut, August 30
Brisbin, C. E. Schuylerville. Dicerca divaricata Say, adult, June 21
Fisher, George. Albany. Alaus oculatus Linn., eyed snapping beetle, adult, June 26
Carpenter, J. S. Marlboro. Byturus unicolor Say, raspberry Byturus, adults on raspberry, May 15
Wilson, Mrs James. Rochester. Attagenus piceus Oliv., black carpet beetle, larvae, October 3. Also Anthrenus scrophulariae Linn., Buffalo carpet beetle, larvae, October 3
Cleveland, P. Scotia. Silvanus surinamensis Linn., saw-toothed grain beetle, adults, April 12
Seiver, W. I. & Co. Angelica. Same as preceding, in flour, May 31
Bates & Broman. Middleburg. Same as preceding, adults, June 20

Diptera

Collins, J. D. Utica. Tabanus atratus Forst., horse-fly, adult, July 14
Kellogg, V. L. Stanford University, Cal. Thecodiplosis piniradiatae Snow & Mills, cotypes on Monterey pine, March 16
Moore, R. M. Rochester. Anopheles punctipennis Say, malaria mosquito, adult, October 6

Siphonaptera

Drew, Miss M. E. Highland Falls. Through State Department of Health. Ctenocephalus canis Curt., dog flea, adult, August 4

Lepidoptera

Todd, Miss Mabel. Gloversville. Euvanessa antiopa Linn., spiny elm caterpillar, larva, June 2

Draper, L. W. Amenia. Same as preceding, June 3

Thomas, M. G. Ticonderoga. Same as preceding, on elm, June 3

Babcock, H. N. Elmira. Same as preceding, larvae, June 5

Morey, C. L. Greenwich. Same as preceding, June 6

Pickering, F. B. Ballston Spa. Same as preceding, on elm, June 6

Zeh, S. D. Hillsdale. Same as preceding, June 6

Russell, C. A. Frankfort. Same as preceding, larvae, June 14

Baker, A. N. Bellport. Same as preceding, June 17

Winchester, M. F. South Amenia. Same as preceding, chrysalids, June 9

Rankin, E. W. Albany. Same as preceding, chrysalis, June 14

Wells, William. Flushing. Basilarchia astyanax Fabr., larva on oak, May 30

Ward, G. E. Ravena. Samia cecropia Linn., Cecropia moth, cocoon, May 6

McEwan, Livingston. Albany. Same as preceding, adult, May 24

Carpenter, J. H. Elnora. Callosamia promethea Dru., Promethea moth, cocoon on lilac, December 9

Hicks, J. J. Jericho. Same as preceding, cocoon, April 25

Darling, Miss F. B. Syracuse. Same as preceding, pupae, April 28

Russell, C. A. Frankfort. Same as preceding, cocoons, June 6

Pierce, Mrs N. A. Solsville. Tropaea luna Linn., Luna moth, adult, May 29. Also Telea polyphemus Cram., Polyphemus moth, adult, May 29

Wheeler, Mrs M. E. East Nassau. Tropaea luna Linn., Luna moth, adult, May 29

Reed, J. A. Watervliet. Telea polyphemus Cram., Polyphemus moth, cocoon and moth, July 15

Huested, P. L. Sparta. Through State Department of Agriculture. Hyphantria textor Harr., fall webworm, larvae, August 25

Bennett, A. T. Tivoli. Same as preceding, larvae on apple, June 9

Scifield, A. G. Hopewell Junction. Same as preceding, larva, September 12

Powers, F. N. Utica. Alypia octomaculata Fabr., 8-spotted forester, larva, June 23

King, F. A. New York City. Same as preceding, larvae on grapevine, July 6

Rich, W. L. Saratoga. Macronoctua onusta Gr., Iris borer, larvae on Iris, July 28

Huyck, J. N. Albany. Same as preceding, August 2

Harris, A. G. North Pelham. Papaipema nitela Guen., stalk borer, caterpillars, July 17

Herrick, C. J. Albany. Xylina antennata Walk., green maple worm, adult, April 27

Horning, C. O. Amsterdam. Same as preceding, larvae on maple, May 30

Westervelt, W. B. Newburg. Same as preceding, larva on soft maple, June 6

Winters, H. B. Brooklyn. Through State Department of Agriculture. Heliothis armiger Hübn., corn worm, larva on corn, October 13

Albright, M. C. West Coxsackie. Melalopha inclusa Hübn., poplar tent maker, larvae on Carolina poplar, June 30

Fremd, Charles. North Rose. Datana ministra Dru., yellow-necked appletree caterpillar, July 20

Brooks, F. M. Athens. Same as preceding, larvae, August 25

Keller, Miss E. L. Eden. Datana integerrima G. & Rob., black walnut caterpillar, larva on pecan, July 28

Bosworth, W. L. Amenia. Schizura concinna Sm. & Abb., red-humped appletree caterpillar, larvae on apple, July 21

Davis, A. G. Schenectady. Same as preceding, young larvae, July 12

State Department of Agriculture. Notolophus antiqua Linn., rusty tussock moth, eggs on box, nursery stock from Holland, March

Tupper, Thomas. Corning. Hemerocampa leucostigma Sm. & Abb., white marked tussock moth, eggs, March 22

Hepworth, J. A. Marlboro. Same as preceding, larva, May 29

State Department of Agriculture. Rochester. Hemerocampa definita Pack., definite marked tussock moth, eggs on poplar, April 5

State Department of Agriculture. West Coxsackie. Tolype velleda Stoll., larch lappet moth, caterpillar on pear, July 25

Machure, G. F. Saranac Lake. Malacosoma americana Fabr., apple tent caterpillar, larvae, June 5

Cox, Townsend, jr. Setauket. Malacosoma disstria Hübn., forest tent caterpillar, larvae, June 11

Humphrey, Miss A. Warsaw. Same as preceding, larvae on maple, June 13

Paladin, Arthur. No. Italy. Bombyx mori Linn., silkworm, cocoons on mulberry, July 21

Niles, T. F. Rye. Through State Department of Agriculture. Alsophila pometaria Harr., fall canker worm, female moths and eggs, November 30

State Department of Agriculture. White Plains. Same as preceding, egg, February 23

Hummer, J. F. Potsdam. Same as preceding, moth, April 26

Smith, J. N. Margaretville. Ennomos subsignarius Hübn., snow-white linden moth, eggs on beech, April 28

State Department of Agriculture. Coxsackie. Ennomos magnarius Guen., notch wing, egg, February 16

Frech, Mrs William. Bayside. Thyridopteryx ephemeraeformis Haw., bagworm, larvae, August 13

State Department of Agriculture. Cnidocampa flavescens Walk., oriental slug caterpillar, cocoon on Japanese maple. Nursery stock imported from Japan, March 23

Van Loan, C. L. Catskill. Sibine stimulea Clem., saddle-back caterpillar, larva, August 30

MacGregor, R. Brooklyn. Same as preceding, September 29

DeFreest, Mynard. Voorheesville. Euclea delphinii Boisd., larvae, August 25

Barden, J. J. Sodus. Phobetron pithecium Sm. & Abb., hag moth, larva, July 27

Burgin, B. O. St Johnsville. Same as preceding, August 14

Struss, Mrs H. W. New York City. Zeuzera pyrina Linn., leopard moth, adult, July 21

Von Schrenk, Hermann. St Louis, Mo. Podosesia syringae Harr., lilac borer, pupa, March 14

Dunbar, John. Rochester. Phlyctaenia rubigalis Guen., greenhouse leaf tyer, moth, January 7

Skinner, R. L. Greenwich. Crambus caliginosellus Clem., sooty webworm, larvae on corn, June 23

Huested, P. L. Port Chester. Through State Department of Agriculture. Mineola indigenella Linn., leaf crumpler, larvae on Crataegus, November 4

Weston, I. A. Syracuse. Plodia interpunctella Hübn., Indian meal moth, adult in graham flour, September 20

Munger, D. M. Glen Cove. Evetria? turionana Hübn., pine bud tortrix moth, larvae on pine, August 29

Dunbar, John. Rochester. Depressaria? atomella Hübn., adults on Cytisus, April 19

McGeoch, A. N. Lake Placid. Through State Conservation Commission. Bucculatrix canadensisella Chamb., birch leaf Bucculatrix, larvae and work on yellow birch, September 7

Steward, Miss M. B. Goshen. Phyllonoryter hamadryadella Clem., white blotch oak leaf miner on oak, October 10

Briggs, J. N. Coeymans. Same as preceding, June 30

Weston, I. A. Syracuse. Tinea pellionella Linn., clothes moth, adult, May 1

Neuroptera

Milligan, A. E. Schuylerville. Corydalis cornuta Linn., Dobson fly, adult, June 29

Hemiptera

Lewis, H. D. Annandale. Tibicen septendecim Linn., seventeen-year Cicada on apple twigs showing oviposition scars, April 13

Lintner, G. W. Summit, N. J. Same as preceding, adult, May 20

Broome, Edward and Robert. Pelham Bay Park. Same as preceding, May 28

Johannsen, J. Raritan Bay Park, Tottenville, S. I. Same as preceding, pupal cases, May 26

Bulson, S. Stony Point. Same as preceding, adults and pupal cases, May 29.

Ward, G. E. Ravena. Same as preceding, adult, May 29
Bolton, A. J. New Rochelle. Same as preceding, June 3
Thomas, G. B. Schuylerville. Same as preceding, June 8
Davey, R. J. Mechanicville. Same as preceding, June 12
Jansen, Frank. Fonda. Same as preceding, June 13
Askins, F. M. Schaghticoke. Same as preceding, June 16
Davies, D. C. Mechanicville. Same as preceding, June 19
Harris, A. G. Pelham. Same as preceding, eggs on locust, July 1
Filer, H. B. Buffalo. Ceresa bubalus Fabr., Buffalo tree hopper, eggs on peach, April 22
Humphrey, Miss E. C. Watervliet. Enchenopa binotata Say, two-spotted tree hopper, nymphs on bittersweet, June 15
State Department of Agriculture. White Plains. Pachypsylla c.-gemma Riley, galls on Celtis occidentalis, May 19
Ferber, Mrs A. J. Rutherford, N. J. Phylloxera caryaecaulis Fitch, hickory gall aphid, adults in galls on hickory, June 2
Wesson, H. W. Eggemoggin, Me. Through Country Gentleman. Chermes floccus Patch, gall on spruce, May 15
Conover, R. T., jr. Bedford. Chermes abietis Linn., spruce gall aphid, galls and adults on spruce, June 10
Clark, Arthur. Garrison. Chermes pinicorticis Fitch, pine bark aphid, adults on pine, June 11
Goodyear, C. W. Tarrytown. Hamamelistes spinosus Shim., adults on birch, June 17. Also Phyllaphis fagi Linn., woolly beech aphis, adults on beech, June 17
Graff, Stephen. Johnstown. Pemphigus ulmifusus Walsh, half-grown galls on red or slippery elm, May 27
Gardner, M. N. Brewster. Phyllaphis fagi Linn., woolly beech aphis, adult on beech, June 15
Howe, Madam. Kenwood. Gossyparia spuria Mod., elm bark louse, adults on elm, May 31
Rogers, J. D. Round Lake. Same as preceding, June 10
Lansing, J. T. Rensselaer. Phenacoccus acericola King, false cottony maple scale, male cocoons on maple, May 18
Hammond, Benjamin. Fishkill. Same as preceding, young on maple, May 26
Briggs, Miss E. M. Oneonta. Same as preceding, adults on maple, May 29
Lawson, T. R. Troy. Same as preceding, June 8
Harcourt, A. J. Kingston. Same as preceding, females and young on maple, July 20
Crossman, L. H. New Rochelle. Same as preceding, August 7
Small, J. W. North Tarrytown. Same as preceding, August 14
Wooster, H. B. Walden. Through State Conservation Commission. Same as preceding, August 16
Unger, H. A. Clinton Heights. Same as preceding, August 17
Buckten, C. W. Mamaroneck. Same as preceding, larvae and adults on maple, August 31

White, Miss J. N. New Rochelle. Through State Conservation Commission. Same as preceding, adults on hard maple, September 9

Nies, C. F. Salamanca. Pulvinaria vitis Linn., cottony maple scale, adults on maple, May 21

State Department of Agriculture. Mount Vernon. Same as preceding, June 16

Kekok, C. C. West Brighton, S. I. Same as preceding, adults and young on soft maple, July 21

Blunt, Miss E. S. New Russia. Lecanium scale, adults and young, June 20

Babcock, H. N. Elmira. Eulecanium nigrofasciatum Perg., Terrapin scale on soft maple, April 8

Yates, M. DeForest. Schenectady. Same as preceding, April 29

Brown, Miss S. A. Unadilla Forks. Same as preceding, June 12

Ward, G. E. Ravena. Eulecanium persicae Fabr., adult on mulberry, May 29

Humphrey, Miss A. Warsaw. ?Eulecanium magnoliarum Ckll., adults, on maple, June 30

Olsen, C. E. Maspeth. ?Saissetia oleae Bern., olive scale, adult on lemon, March 5. Also Chrysomphalus smilacis Comst., smilax scale on ?smilax, March 29. Also Lepidosaphes beckii Newm., adult on lemon, March 5. Also Parlatoria proteus Curt., orange chaff scale, adult on orange, March 5

Harris, S. G. Tarrytown. Chionaspis pinifoliae Fitch, pine leaf scale, eggs on Scotch pine, September 27

Stene, A. E. Kingston, R. I. Diaspis carueli Targ., juniper scale, adults on Swedish juniper, September 27

Thompson, Miss Rhoda. Ballston Spa. Aulacaspis rosae Sandb., rose scale, egg on rose, November 18

Ritch, E. J. Kingston. Same as preceding, April 26

Atwood, G. G. France. Through State Department of Agriculture. Epidiaspis piricola DeGuer., pear scale, adult on pear imported from France, January 16

Ellwanger & Barry. Rochester. Aspidiotus? ostreaeformis Curt., European oyster scale, adult on willow, May 12

Gibson, Arthur. Ottawa, Canada. Same as preceding, adults, October 11

Earl, Mrs E. A. Ballston Spa. Aspidiotus perniciosus Comst., San José scale, young on apple, May 18. Also Lepidosaphes ulmi Linn., oyster shell bark louse, young on apple, May 18

Lane, A. M. Schenectady. Aspidiotus perniciosus Comst., San José scale, young on apple, April 1

Akins, W. J. New Baltimore. Same as preceding, young, August 8. Also Lepidosaphes ulmi Linn., oyster shell bark louse, on French lilac, August 14

Schofield, R. Coeymans. Aspidiotus perniciosus Comst., San José scale, adults and young on apple, September 15

Field, J. E. New York City. Lepidosaphes ulmi Linn., oyster shell bark louse, eggs on balm of Gilead, April 21

Hudson, G. H. Plattsburg. Lygus pratensis Linn., tarnished plant bug, adults on aster, October 8

Yeomans, Albert. Walworth. Poecilocapsus lineatus Fabr., 4-lined leaf bug, work on currant, June 13

Orthoptera

Brown, M. R. Merrickville. Ischnoptera pennsylvanica DeG., June 19

Moore, W. F. Mechanicville. Through Troy Press. Gryllotalpa borealis Burm., mole cricket, August 26

Plecoptera

Robinson, W. G. Greenfield Center. Pteronarcys biloba Newm., adult, May 26

Ephemerida

Lane, B. H. Coxsackie. Hexagenia variabilis? Eaton, June 2

Thysanura

Taber, S. R. Milton. Smynthurus arvalis Fitch, adults on raspberry, May 24

ZOOLOGY

Donation

Mammal skull

Clarke, Dr John M. Albany

Walrus, Odobenus rosmarus (Linnaeus)..... 1

Birds

Publishers of Country Gentleman. Albany

Purple finch, Carpodacus purpureus (Gmelin)..... 2

Jordan, A. L. North Greenbush

Red-winged blackbird, Agalaius phoeniceus (Linnaeus). 1

Paladin, Arthur. Albany

Yellow-bellied sapsucker, Sphyrapicus varius (Linnaeus). 1

Seymour, Miss May. Lake Placid

Water thrush, Seirus noveboracensis (Gmelin)..... 1

Stead, Mrs J. C. Brooklyn

Gannet, Sula bassana Linnaeus, mounted..... 1

Amphibians

Latham, Roy. Orient Point, Suffolk county

Four-toed salamander, Hemidactylium scutatum (Schlegel) 1

Fishes (in alcohol)

Bean, Dr Tarleton H. Albany
- Golden shiner, Abramis crysoleucas (Mitchill)..... 1
- Lake chub, Semotilus bullaris (Rafinesque)..... 1
- Creek chub, Semotilus atromaculatus (Mitchill)..... 1
- Horned dace, Notropis cornutus (Mitchill)..... 1
- Buckeye shiner, Notropis atherinoides Rafinesque..... 1
- Spawn eater, Notropis hudsonius (De Witt Clinton).... 1
- Mud sucker, Exoglossum maxillingua (Le Sueur).... 1

Invertebrates

Bean, Dr Tarleton H. Albany
- Leech, Trachelobdella vivida (Verrill)..... 2

Patten, Mrs M. M. Albany
- Sea fan, Rhipidogorgia flabellum (Linnaeus)..... 12

Sanford, Gen. George D. Albany
- Tarantula, Dugesiella hentzi (Girard)..... 1

Exchange

Birds

Ward's Natural Science Establishment. Rochester
- Black-backed gull, Larus marinus Linnaeus, skin..... 1
- Iceland gull, Larus leacopterus Faber, skin..... 1
- Harlequin duck, Histrionicus histrionicus (Linnaeus) skin 1
- Wood ibis, Mycteria americana Linnaeus, mounted..... 1
- White gyrfalcon, Falco islandus Brünnich, skin..... 1
- Snowy owl, Nyctea nyctea (Linnaeus) skin..... 1

Purchase

Mammals

Paine, Silas H. Silver Bay
- Virginia deer, Odocoileus virginianus borealis Miller, fawn, mounted..... 1
- Porcupine, Erithizon dorsatus (Linnaeus) mounted..... 2
- Fisher, Mustela pennanti Erxleben, mounted..... 1

Rhodes & Gilbert. Lander, Wyoming
- Elk, Cervus canadensis (Erxleben), skins..... 3

Ward's Natural Science Establishment. Rochester
- Opossum, Didelphis virginiana Kerr, mounted group.... 10
- Harbor porpoise, Phocaena phocaena (Linnaeus), cast... 1
- Bottle-nosed dolphin, Tursiops tursio (Fabricius), cast... 1
- Fox squirrel, Sciurus rufiventer Geoffroy, skins..... 4

Birds, mounted

Barker, Fred. Parker's Prairie, Minnesota

Pied-billed grebe, Podilymbus podiceps (Linnaeus)	5
Black tern, Hydrochelidon nigra surinamensis (Gmelin)	3
Mallard, Anas platyrhynchos Linnaeus	3
Least bittern, Ixobrychus exilis (Gmelin)	3
Virginia rail, Rallus virginianus Linnaeus	5
Sora, Porzana carolina (Linnaeus)	5
Florida gallinule, Gallinula galeata (Lichtenstein)	1
American coot, Fulica americana Gmelin	5
Upland plover, Bartramia longicauda (Bechstein)	2
Killdeer, Oxyechus vociferus (Linnaeus)	4
Marsh hawk, Circus hudsonius (Linnaeus)	4
Coopers hawk, Accipiter cooperi (Bonaparte)	3
Red-tailed hawk, Buteo borealis (Gmelin)	5
Broad-winged hawk, Buteo platypterus	3
Long-eared owl, Asio wilsonianus (Lesson)	4
Great-horned owl, Bubo virginianus (Gmelin)	4
Ruby-throated humming bird, Archilochus colubris (Linnaeus)	1
Grasshopper sparrow, Ammodramus savannarum australis	5

Paine, Silas H. Silver Bay

Loon, Gavia immer (Brünnich)	3
Herring gull, Larus argentatus Pontoppidan	1
Black duck, Anas rubripes (Brewster)	3
Bittern, Botaurus lentiginosus (Montagu)	2
Great blue heron, Ardea herodias Linnaeus	3
Red phalarope, Phalaropus fulicarius (Linnaeus)	1
Woodcock, Philohela minor (Gmelin)	4
Spotted sandpiper, Actitis macularia (Linnaeus)	2
Ruffed grouse, Bonasa umbellus (Linnaeus)	7
Goshawk, Astur atricapillus (Wilson)	5
Duck hawk, Falco peregrinus anatum (Bonaparte)	4
Sparrow hawk, Falco sparverius Linnaeus	6
Osprey, Pandion haliaetus carolinensis (Gmelin)	3
Kingfisher, Ceryle alcyon (Linnaeus)	4

Birds (skins or in flesh)

Jordan, A. L. North Greenbush

Barred owl, Strix varia Barton	1

Ward's Natural Science Establishment. Rochester

Ground dove, Columbigallina passerina terrestris (Chapman)	2

Birds' nests and eggs

Paine, Silas H. Silver Bay

Pied-billed grebe, Podilymbus podiceps (Linnaeus), nest and 3 eggs
Bittern, Botaurus lentiginosus (Montagu), nest
Great blue heron, Ardea herodias Linnaeus, nest
Coot, Fulica americana Gmelin, nest
Killdeer, Oxyechus vociferus (Linnaeus), 3 eggs
Ruffed grouse, Bonasa umbellus (Linnaeus), 7 eggs
Marsh hawk, Circus hudsonius (Linnaeus), nest and 1 egg
Goshawk, Astur atricapillus (Wilson), nest
Sparrow hawk, Falco sparverius Linnaeus, nest and 2 eggs
Barred owl, Strix varia Barton, nest
Screech owl, Otus asio (Linnaeus), nest
Great horned owl, Bubo virginianus (Gmelin), nest and 3 eggs
Kingfisher, Ceryle alcyon (Linnaeus), 5 eggs
Kingbird, Tyrannus tyrannus (Linnaeus), nest and 3 eggs
Crested fly-catcher, Myiarchus crinitus (Linnaeus), nest and 3 eggs
Phoebe, Sayornis phoebe (Latham), nest
Eave swallow, Petrochelidon lunifrons (Say), 2 nests
Barn swallow, Hirundo erythrogaster Boddaert, nest and 3 eggs
Red-eyed vireo, Vireosylva olivacea (Linnaeus), nest and 1 egg
Blackburian warbler, Dendroica fusca (Müller), nest
Chickadee, Penthestes atricapillus (Linnaeus), nest and 4 eggs
Bluebird, Sialia sialis (Linnaeus), nest and 2 eggs

Reptiles (casts)

Ward's Natural Science Establishment. Rochester

Rattlesnake, Crotalus horridus Linnaeus, cast..... 1
Garter snake, Thamnophis sirtalis (Linnaeus) cast..... 1
Painted turtle, Chrysemys marginata Agassiz, cast..... 1
Snapping turtle, Chelydra serpentina (Linnaeus) cast... 1

Fishes (mounted)

Paine, Silas H. Silver Bay

Small-mouthed black bass, Micropterus dolomieu Lacépède 1
Common sunfish, Eupomotis gibbosus (Linnaeus)..... 2
Yellow perch, Perca flavescens (Mitchill)..... 1

ARCHEOLOGY

Excavation

By **A. C. Parker** and **E. R. Burmaster**

Lima, Livingston county

Copper beads	20
Arrow points, triangular	7
Flint, worked	1
Crushed pottery vessels, may be restored	5
Celts	5
Arrow points from surface	25
Old type crude shell beads	65
Brass or copper cylinder ring	1
Flat ring, ends tied with cord	1
Worked shell ornament	1
Wampum beads, string of	50
Shell beads, Roanoke style	3
Brass coil	1
Awls	3
Buckskin fragments	5
Paint, quantity of red	1
Arrow points	12
Perforated ball joint	1
Shell beads	5
Triangular arrow points	2
Bird mandibles	3
Portion woven bag, containing many beads	1
Muller stone, fine specimen	1
Brass or copper spiral	1
Large copper ring ornaments of native manufacture	3
Copper beads	25
Fragment woven bag	1
Pitching tool	1
Flakers	3
Arrows, all three from one grave	3
Charred corn box	1
Hammer stone or muller	1
Copper spiral	1
Shell beads	20
Arm ornament containing 640 beads	1
Crude shell beads	21
Bone comb, early contact form	1
Unio shell article	1
Awl, worked tooth, 4 flints	6
Large brass or copper ring ornaments	4
Disk or roanoke wampum beads	9
Large natural made wampum beads	5
Buffalo horn tips worked into beads	2
Brass spiral	1

Long tubular brass ornament..... 1
The five last mentioned articles on original thong preserved by copper salts
Woven bag fragment..... 1
Disk beads..... 94
Copper beads..... 2
Small brass tubes..... 75
Copper disk, broken..... 1
Brass beads..... 15
Plum pit dice..... 24
Brass or copper tubes (long)..... 7
Wampum and roanoke beads..... 200
Copper beads..... 6
Fragments of buckskin..... 2
Bone ornament worked from turtle carapace..... 1
Unio shell articles..... 2
Antler "pins" polished..... 3

By **J. F. White**
Mount Morris, Livingston county
Copper ornament..... 1

Donation

J. A. Van Denburg. Eagle Bridge
Celt..... 1
Stone knife..... 1
Chipped arrow points..... 55

Clyde B. Hay. Hackensack, N. J.
Collected from South Bethlehem
Arrow points..... 33
Miscellaneous stone points..... 16
Spears..... 6
Fragmentary flints..... 11

C. E. Durkee. Saratoga Springs
One fragment polished pick..... 1
Fragment pottery vessel rim..... 1
Chisel gouges..... 2
Slate knife..... 1
Flint points..... 11
Knife, chert..... 1
Cutting edge of celt..... 1
Fragments of points..... 16
Knives..... 3
Drills..... 3
Triangular points..... 2
Miscellaneous notched points..... 25
Burnt scraper, notched..... 1

Holden Collection, Box 1
Bronze buckle..... 1
Catlinite tube-pipe..... 1

Perforated stone	1
Copper chisel	1
Skinning knife	1
Barlow knife, Fort William Henry	1
Pipe, with card attached	1
Banner stone	1
Bullet mold	1
Barlow (same as above)	1
Confederate dirk	1
Broken banner stone	1
Huge clasp knife from French Mt	1
Perforated stone	1
Copper hatchet	1
Heart-shaped birch bark, with quill work	1
Key from Fort George	1
Iron hatchet	1
Arrowhead — Dodge Sweet farm	1
Banner stone	1
Needle-stone	1
Perforated stones	
Small box containing shell beads	
Very fine spear points	4
Skinning knife	1
Antique buckle	1
Fine gouge	1
Small box bullets, shrapnel etc. from Fort George	1
Aztec cup, in small box	1
Horn cup	1
1 box miscellaneous minerals	1
1 small box S. C. arrow points	1
Package arrow points	1
2 boxes unidentified arrow and spear points	50

Holden Collection Box 2

Gouge	1
Gouge	1
Pestles	4
Large pestle, Baker farm	1
Discus	1
Iron axe	1
3 iron axes	3
Large stone axe	1
Stone axe — crude	1
Stone chisel	1
Stone hatchet	1
Stone axe	1
Stone axe	1
Iron adze	1
Stone axe	1
Chisel	1

Dressing stone..... 1
Gouge..... 1
Gouge..... 1
Broken pestle..... 1
Iron axe, restored handle..... 1
Fragments steatite vessel..... 2
Celt..... 1
Fine celt..... 1
Brick from Ticonderoga..... 1

Gordon, Patchogue, L. I.

Worked oval stone..... 1
Notched sinkers..... 4
Grooved axe, crude..... 1
Chipped stones..... 4
Celt belts..... 4
Celts, fine specimens..... 3
Celts, crude..... 5
Chert arrow points.....
Reject flints..... 32
Ring of European trade wampum..... 1
Chisel..... 1
Pipe — complete..... 1
Triangular points..... 97
Long slender points..... 25
Chert points, miscellaneous..... 48
Fragments of clay pipes..... 3
Miscellaneous flints..... 30
Ohio arrow points..... 13

ETHNOLOGY

Seneca specimens

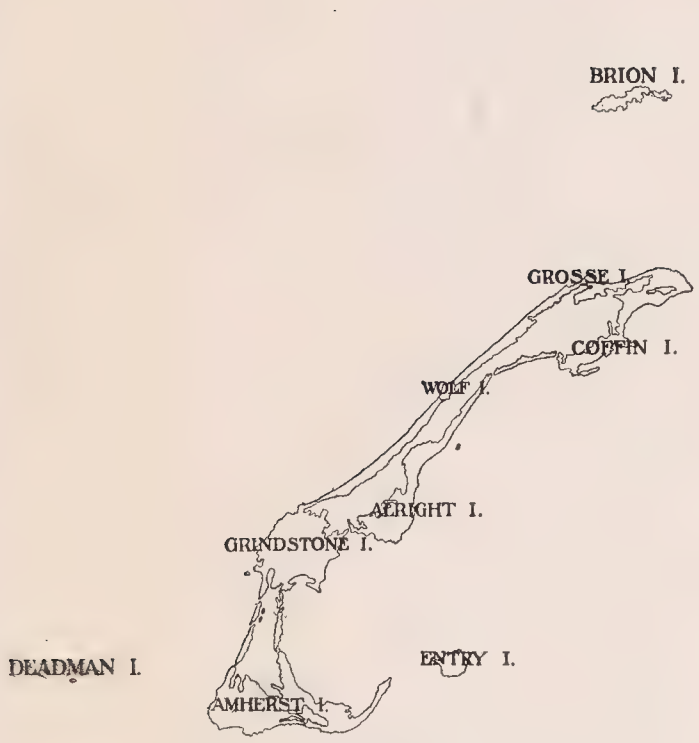
Flat corn basket..... 1
Carrying basket..... 1
Game bowl..... 1
False face..... 1
Wooden spoon..... 1
Headdresses..... 3
Wooden bowls..... 2
Sap tubes..... 5
Bow and arrows..... 6
Wooden spoons..... 2
Rattles..... 4
Wooden trough..... 1
Brooches..... 30
Earrings..... 2
Decorator's tools..... 15
Bracelets, silver..... 2
Arm bands, silver..... 2

Onondaga specimens

False face	1
Husk dolls	2
Pipe and decorated stem	1
Brooches	6
Earrings	2
Dice of peach pits	6
Brooches	6
Silver earrings	2

Cayuga specimens

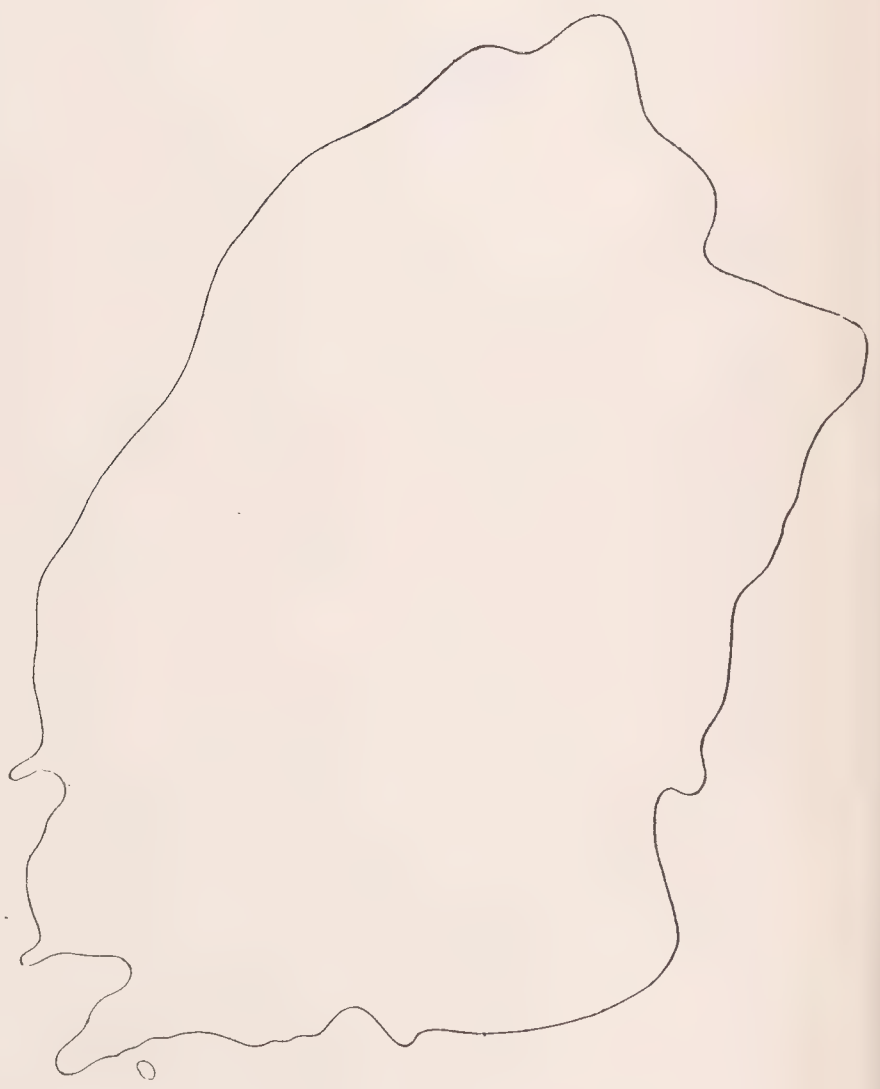
Baby board	1
Log house	1



Present outline. All long arms are sand

Outline at 5 fathoms

Cutline at 10 fathoms



Outline at 20 fathoms

Magdalen Islands. Outlines indicating their loss of area by wave action with concurrent submergence. All are in the same scale.

NOTES ON THE GEOLOGY OF THE GULF OF ST LAWRENCE

BY JOHN M. CLARKE

THE DEMOISELLES OF ENTRY ISLAND

On the Magdalen islands in the Gulf of St Lawrence the higher land elevations are mammiform hills which rise everywhere with striking symmetry and entire absence of irregularities into softly contoured grassy domes. I have termed these hills *demoiselles,*[1] taking the name from Demoiselle hill, one of their number, which fronts the sea on the east coast of Amherst island. Over all the larger islands these pretty hills rise to relatively notable heights; except for them the islands are flat, low-lying plateaus of sandstone and sand dune, but the rounded heads of the demoiselles, showing none of their rocks except where eaten into by the sea or weather, command the eye by the abruptness with which they rise from the plain. Wherever they occur all have the same general direction and relation to each other. Their course lies generally northeast-southwest, like the trend of the island group itself. On the broad central part of Amherst they lie in well-nigh parallel rows, but their height is greatest on Entry island. St Lawrence hill (so named by S. G. W. Benjamin, author, forty years ago, of some fascinating sketches of these islands) approximates 670 feet and is the highest of all and the most symmetrical in the remarkable array of demoiselles in that island to which I desire, among other things, to direct special attention. On Amherst these hills lack some of the elements of symmetry and beauty which are presented by those on Alright and Entry islands. It is in the latter they attain their most striking appearance and on Alright their greater isolation makes them a somewhat more effective feature to the passerby. Indeed the passer seldom sees the hills of Entry except as a skyline, for this island lies apart from the rest of the group and from all regular connection with them. The steamer threads the precarious channel between the sand spits of Amherst and Entry but the hills of Entry are on its farther side and face the gulf. In my general description of the islands and their geology the nature of these hills was discussed and some suggestions made as to their origin, but much was left unsaid. Since then I have had opportunity to study the structure of Entry island, which I had not before visited.

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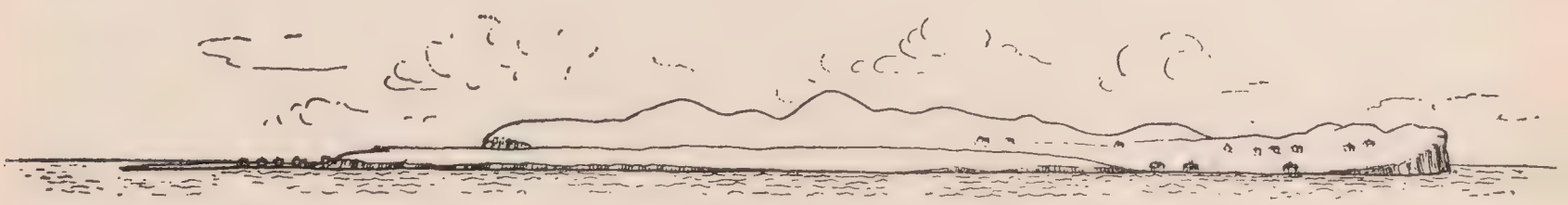
[1] Observations on the Magdalen Islands, 1911, p. 12.

One reaches Entry from Amherst harbor by the help of a fisherman's shallop, and though isolated from the rest of the little archipelago, it is easy enough to reach in a summer's breeze, less easy in a summer's blow, and the island is quite off the world in the gales that blow up without warning on the uncertain gulf. Entry is the park and arcadia of the Magdalens. The very beauty of its isolation, the fertility of its soil, the alluring grace of its contours, the air of relative prosperity among its slender population, invite to studious repose. It is a little seagirt domain where no one asks a favor of the outside world, save to get there and to get away again. Its proportions are slender, measuring two miles in diameter both north-south and east-west; taking on a rather five-sided shape, with the east shore due north and south. From its northwestern angle a long sand spit reaches out toward the great nine-mile spit from Amherst (Sandy Hook), these long arms almost clasping hands across the narrow channel in which by fair weather lies the steamer's path.



Entry island in profile, seen from the west

The eastern shore is lined and buttressed by the range of demoiselles. The sea has eaten into them making all that shore a row of sheer and inaccessible cliffs. The island remains, it may well be said, because these hills have defied the storms of the gulf and have guarded the lower lands behind them against the tooth of the sea.

The views from the shore cliffs and uplands of the island are of wondrous sweep and beauty — toward the west and north the cliffs and low-lying shores of the other islands, the gray rocks of Amherst, the red walls of Grindstone, the more distant hills of Alright fading with distance into the blue sands of Grand Entry and Old Harry; on the south the misty outline of St Paul's island and Cape Breton fifty miles away, and at the east the vast expanse of waters of the gulf. Of a fair day in summer the island is a gem of emerald in an idyllic Aegean setting. In autumn's storms it is a foothold against the seething uproar of the gulf, and in winter it lies chained to its sister islands by bands of ice which sever it and them from the world outside, save for the cable and the marconi.

History and settlement. In my previous paper I have taken occasion to refer incidentally to the fact that since the days of the

Entry island — Insulated sandstone table on north shore; showing white sand layer and pebble bed

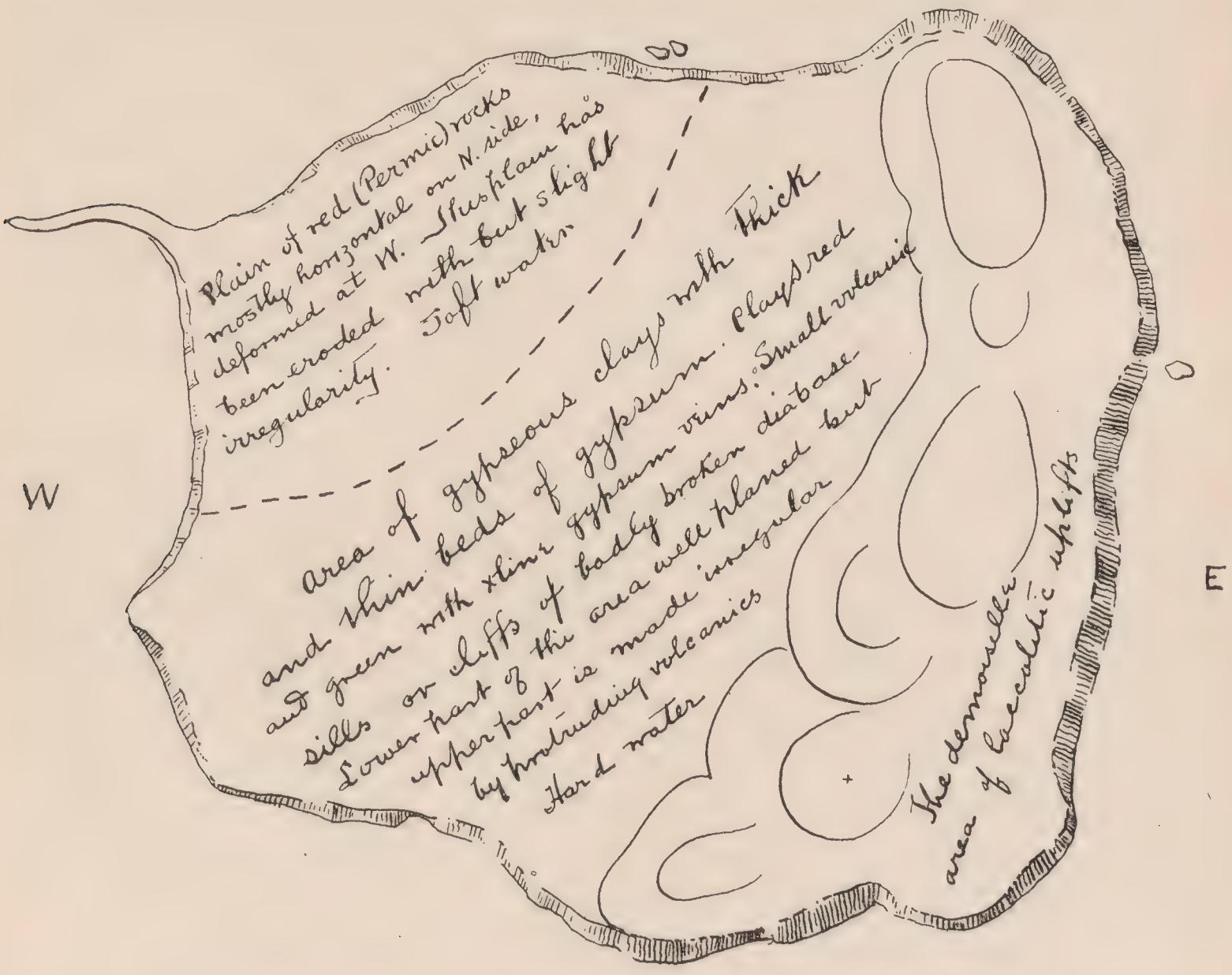
earliest charts on which this island has been given any designation, its name has been unaltered. It was the Ile de l'Entrée to the skippers of the sixteenth and seventeenth centuries. Standing at the door of the island cluster, as the navigator swung from the southward of Newfoundland through Cabot strait, its name registers its office. The records of French settlement on Entry have entirely passed away. Today the population is wholly Scotch and Scotch-Irish and the old stock is the Cassidys, Dixsons, McCleans and Collinses, stock which came in from Nova Scotia a century or more ago and has multiplied almost wholly by intermarriage. There are about thirty families on the island, each related in near or far degree to all the rest and it is commonly said that no outsider has settled in this community in time out of mind. The laws of eugenics which discountenances such close inbreeding is here honored in the breach and the youth of the place instead of weaklings, anemics and decrepits, are sturdy and wholesome. For every human head there must be five head of fine cattle, and milk is actually freer than water, for potable water is scarce; if one will not drink milk then let him drink cream.

The settlers have built their homes for the most part under the lee of the eastern hills, and thus away from the most fertile parts of the ground. So from the beach at Northwest point two wheel ruts crunch their way over buried walrus bones, wander through the grass, bounded on one side, as they pass over the badly drained plaster soil, by fens and bogs sheeted with fleurs-de-lis, on the other by outside cellars made of an overturned whale boat sawed in twain or opened at the side, turfed over on keel, here and there a Barbados puncheon for the geese, till they reach the southeast cliffs; this is the only road the island boasts.

The farmer-fishermen are all tenants of the proprietor — the estate of Sir Isaac Coffin. No land is held by them in fee; notwithstanding the efforts made by the islanders and their friends in the Quebec Parliament to exact concessions from the proprietor to enable freehold, the settlers of Entry have taken no advantage of these concessions; and all the surface of the demoiselle hills is still unleased crown land, pasture to all the community.

The soil divides itself in quality in accordance with the rock that lies beneath it, for it is all residual. Hence over the thin soil of the larger demoiselles at the eastern side there is only grazing for the sheep and cattle; on the lower slopes of the mid-island, where lesser volcanic domes are mingled with the sink holes and roughened sur-

face of the gypseous clays, there is grass in plenty and much soil deep enough for oats and potatoes; but it is on the low plateau of red sandstone near the west and north where the soil is of extraordinary richness, and grain, potatoes and gardens grow to a fulness restricted only by the shortness of the season. The fertility of this soil is barely tried by the inhabitants; on the lowlands it is hardly scratched from year to year to invite the less exhausted parts to the top — but withal, with minimum of labor, always reluctant, it yields enough; the people are fairly well to do and want is unknown among them.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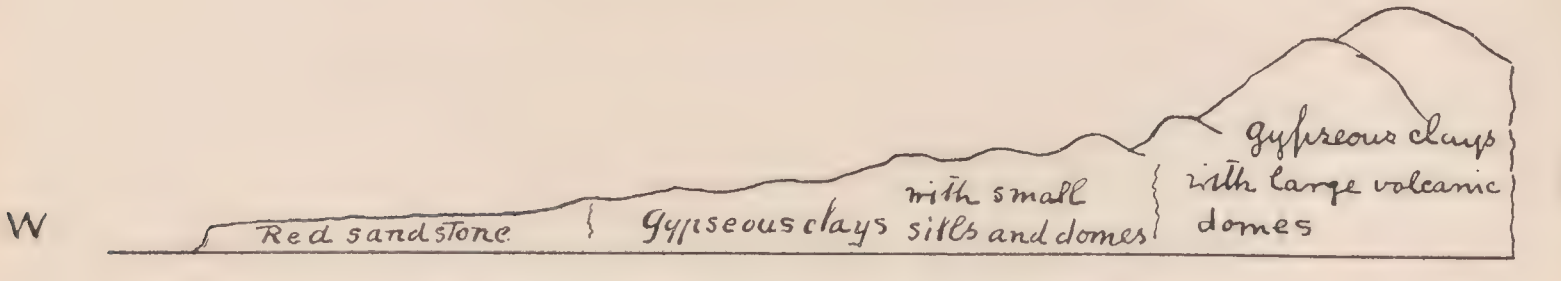
E
Plain of red (Permic) rocks mostly horizontal on N. side, deformed at W. Slush lam has been eroded with but slight irregularity.
Soft water
Area of gypseous clays with thick and thin beds of gypsum. Clays red and green with xlins gypsum veins. Small volcanic sills or cliffs of badly broken diabase
Lower part of the area well planed but part is made irregular by intruding volcanics
Hard water
The dense yellow area of basaltic uplifts

Sketch plan of Entry island and its topographical divisions



West-east cross section of Entry island

Added to all the possibilities of the soil are the treasures of the sea; the seal, the lobster, cod, herring, mackerel and cod again, each in its season — a rich horn of plenty for any one who will, at some cost of rough work, reach out and take. Two hundred thousand

Entry island. Gypseous rock with veinlets of crystalline gypsum.

Entry island. The gravel layers within the red sandstone, exposed by wind erosion of the overlying beds.

Entry island. A comfortable home, with demoiselle topography in the background.

lobsters were caught on Entry in 1911, but it is easy work to drop a lobster trap and pull it up again loaded. Even at three cents a lobster this means something for the frugal islanders. And yet the other wealth of the sea might be made vastly more productive than it now is. But why make muckle mair? This is the Isle of Repose, its treeless slopes and plain, the shadeless groves of the stagyrite.

Topography. The contour of Entry is suggested by the accompanying east-west cross section which may be applied to the plane map.

Red sandstone plateau. The red Permic sandstones of the lower plateau are restricted to the northwest corner on both sides of the sand spit and here they are displayed in all their brilliance of color, made more effective than elsewhere on the Magdalens by the way in which the winds have stripped it of its overlying soil. I have before directed attention to the constitution of these, the latest sediments of the islands, and may here only restate that the striking band of glistening white residual sand lying everywhere beneath the vegetable mold is here brilliantly developed in every cliff section. The layer of angular diabase pebbles which lies directly beneath this white sand, is even more conspicuously displayed on Entry than anywhere else on the islands and there are broad areas on the north side where soil and white sand have been torn away by the winds, exposing this layer of angular gravel in very striking display. This widespread deposit lying on the summit of the red sandstone plateau and incorporated into it points to an obscure but rather extraordinary phenomenon, as though a final stage in the deposit of the sandstone had been the sweeping over the sea floor of an extensive mass of volcanic debris. From any knowledge I have now I dare not say that it points to a contemporary outburst of volcanic debris, or to an overriding tidal wave which may have even covered the low cliffs after they were raised to their present elevation.[1]

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[1] The tidal wave action suggested is not too remote. We have evidence at hand that such things still happen in the gulf. On January 7, 1912, the sea rose suddenly in the gulf at 7 p. m., a few hours after high tide, and swept all the lower levels of the Gaspé coast from Cape des Rosier to Percé, causing much damage on the beaches, submerging the stores and other buildings on the "point" at Gaspé Basin and rising to a height of six to eight feet above highest tide. The wave was not followed by another and the water subsided promptly. The action suggests a submarine earthquake of slight moment in the northern gulf, quite possibly some dislocation along appalachian fault lines in the older rocks beneath the upper gulf, but the

Beneath the soil and on the pebble bed lie the bones of walrus in considerable quantity all about the northwest point. I have referred to the occurrence of these in similar position on the other islands. They date back to a century and more ago when the walrus was regularly hunted on the islands, being driven upon the low shores from the ice pans and slaughtered at leisure by the fishermen. Over these bones the soil has formed to a depth of several inches.

The sea has cut away this rock with great rapidity, and is yearly changing the outline of this northwestern shore. When Mr S. G. W. Benjamin wrote his inviting sketches of the islands[1] he gave a picture of two rock pillars off the north shore, long known as the "Old Man" and the "Old Woman." They fell under the waves some twenty years ago, and since their destruction new rock tables and monuments have been carved from the island mass.

The volcanic-gypsum belt. This area makes a broad belt across the island and its topography is that quite characteristic of many gypsiferous regions — a rather badly broken surface, due in no small part to hydration and solution. It is a region of short drainage ways leading down from the hills and running into or through small bogs and marshes, blind sink holes, irregular and formless knolls. But it is for the most part a fairly fertile soil. In geology this belt is composed of gypseous clays and more solid masses in extreme disorder traversed by veins of the crystallized sulfate, the rock masses varying greatly in color from greens and grays into purple-red and pink. While the absence of an orderly bedding is a very evident feature of these extensive deposits there are places where the beds are clearly arranged in horizontal layers with alternating colors. I have here given an illustration in approximately correct tints of a cliff exposure where light pinks and blue grays produce a very surprising color effect. This is on the south shore. With and among these gypseous beds are frequent igneous masses exposed

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seismograph at Albany failed to record any such motion on the day mentioned. Such a single wave of greater magnitude might well have washed the beach debris over the red sandstone cliffs by a single pulsation affecting simultaneously all these low cliffs of all the islands alike, burying and killing the grass with its mantle of gravel which has eventually worked its way down into the decomposing rock.

[1] The Atlantic Islands as Resorts of Health and Pleasure, chap. 4, 1878; The Cruise of the "Alice May"; the Century Magazine, 1884.

Some recent magazine articles by Yeigh and by Amy refer to these rocks as still standing — statements quite comparable in accuracy to many others regarding the islands that these short trip artists have chosen to put down.

Entry island — Gypseous cliffs on south shore.

sometimes as erect dikes of diabase, deeply rotted and at others thin single sills lying at steep angles and constituting the projecting points of the rocky shore. In the midst of these volcanic-gypsum masses, however, are well-stratified green and gray sandstones, exposed most plentifully nearer the contact with the soft red sandstones at the southwest of the area; and in the very heart of the gypsum clays I have located in the midst of great disorder of the strata, dolomites and shales carrying fossils of the same species as those which have been described from Grindstone island. The combination of rocks here is not unlike that on Grindstone island, and elsewhere in the archipelago, but it is more forcibly expressed. The gray sandstones prevail in greater extent on Grindstone and Amherst, and on the former the fossiliferous rocks are found in close juxtaposition to the gypsum. There is on Entry no such development of the commercial gypsum as on Grindstone but the same disordered condition of the gypseous clays and the same intimate association of these with volcanic intrusions. This volcanic-gypsum area is the foreland of the distinctively volcanic demoiselle range of hills; its volcanic intrusions are not conspicuously dome-shaped, but isolated single dikes or sills with no contact effects except those indicated by the existence of the gypseous masses. Here, as on Grindstone, there are many evidences of angular diabase blocks entirely inclosed in gypsum, forming a diabase conglomerate with crystalline gypsum cement. The dislocations of the sandstones and limestones are purely local and of slight extent. It is quite evident that for the red sandstones the horizontal position general in all the other islands is normal here, though these are somewhat out of place on the west shore; and likewise the gray sandstones, elsewhere horizontal, are here thrown into a steep dip where they appear on the south. The disorder of arrangement shown in the cliff sections of this belt is expressed by the irregularities of the surface of the ground.

The demoiselles. This belt of breasted hills begins at the north, forms all the eastern third of the island, spreading a little westward at the south. The most impressive and largest are at the north but it is toward the south that the number is greatest. In a certain sense they are arranged in a single row close against the sea and into their substance the sea has eaten its way, but at the south lesser hills spring up about the base of the larger, becoming smaller in size as they recede from the main series, but always in this more diminutive form retaining their perfect symmetry. I

Sky line and south-east sea front of demoiselles, Entry island

have not attempted to enumerate these demoiselles; the number of their summits seems to depend on the angle at which they are viewed. Often one of the larger, seen from one point, resolves itself into duplicate curves if looked at from another. In all the curves are of essentially the same arc, large and small, and their individuality is more pronounced than on the other islands.

In respect to their geology these demoiselles are to be regarded as more pronounced expressions of the conditions presented in the volcanic-gypsum belt, the volcanic form herein being developed in topography freer of complication with associated rock masses. Yet it is important to avoid the conception that there is any real distinction in composition or genesis between this region of hills and the foreland. The sea has cut well into the heart of these demoiselles and the weather has eaten into their surfaces; and so far as I have observed the volcanics here are accompanied and often overburdened by gypseous deposits alone. The volcanic masses are lenses composed of palpably curved layers and it is this curvature into domes with quaquaversal dip that has produced the contours of the hills. The bedding of these masses is sometimes better defined in one part of a given section than in another, and in no case that I have observed is the volcanic mass free of its overburden of gypseous rock save where meteoric agencies have apparently weathered it away and brought to light the crumbling curved top surface of the diabase. So on all this steep eastern shore section of the demoiselles there are high cliffs of gypse-

Entry island. The northern demoiselles.

Entry island. Surface of demoiselle showing loose volcanic blocks.

Entry island. Outside cellar made of half a whale boat.

ous rock as well as of the volcanics, and it becomes very evident to the observer that the igneous masses have been exposed in their surface contours by meteoric solution of the gypsum overburden. That this is the process of removal of the gypseous rock is made clear by its presence in the shore sections of masses, interstitial between the laccolitic volcanics in cliffs which equal in height the volcanic domes themselves; and for this reason I am disposed to believe that the progress of time will bring the volcanic domes into even stronger topographic contrasts. It is to be presumed that the intrusive masses are not all at the same horizon in the rocks and that the interstices or intervals between as well as for the most part the surface over them is occupied by the gypseous masses. This part of Entry does not however show certain other accompanying and contact effects of the laccolites which are shown

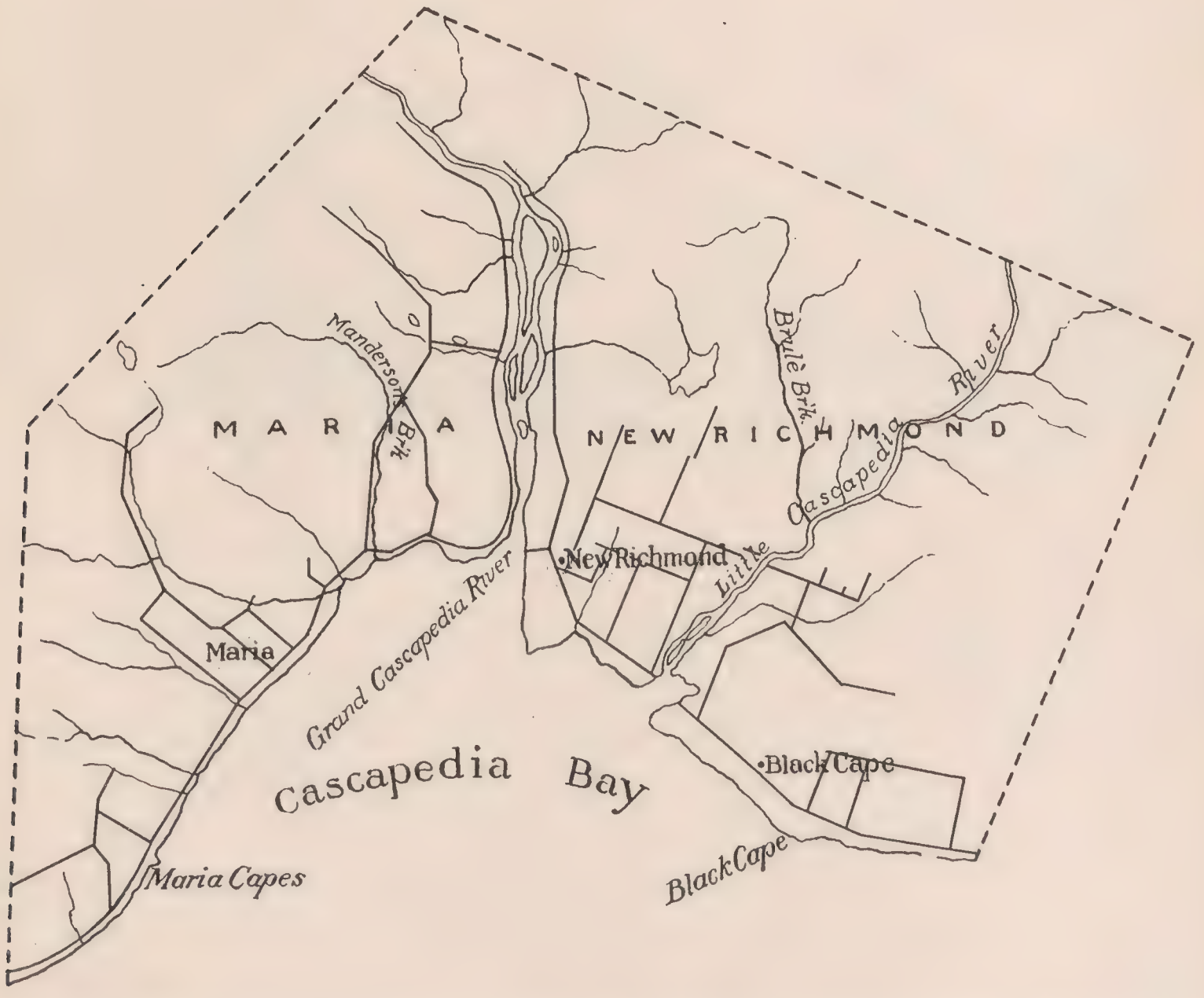
Curved volcanic layers in a section of a demoiselle, east coast of Entry island

in the rest of the islands. These I have elsewhere referred to and they have chiefly to do with the relations of the laccolites to the gray sandstones which are best displayed on Grindstone and Alright islands. On Amherst island it is made very clear that the red sandstones are of later date than the gray, for they lie unconformably over them. But on Grindstone island the red sandstones pass laterally into the gray and much harder sandstones of Point au Meule, the steamer landing at that place. Point au Meule is a demoiselle exposing no igneous core; the gray sandstones alone compose the sea cliff which rises well nigh to the top of the dome. This hardened and highly silicious sandstone mass is soon replaced by the gypsums at the north as it is by the red sandstones at the south. Similar phenomena are seen in the shore domes on Alright, the bolder heads displaying gray sandstone fronts, and in these

cases I believe the overburden of the laccolites is sandstone which has been lifted and in some measure compacted and altered by the igneous lenses beneath. It is not to be understood that these expressions of contact change are the only ones here appearing. The gypsum overburden is also evident on both islands, but the greater resistance of compacted sandstone to the wear and tear of the sea and weather has made these presentments conspicuous, while they are absent on Entry because the ingredients are wanting, the gray sandstones being only very sparsely represented.

A REMARKABLE SILURIC SECTION ON THE BAY OF CHALEUR

This is a preliminary note in regard to a Siluric section of apparently extraordinary thickness exposed along the north shore of the Bay of Chaleur, just east of the mouth of the Little Cascapedia river. The prosperous village of New Richmond lies here



Sketch map of Cascapedia bay and rivers, Bay of Chaleur, giving location of the Black cape section

in the broad depression of the Grand and Little Cascapedia rivers. In the valley of the two rivers the rock series lies deeply buried, but crossing the Little Cascapedia eastward, the rock comes to the sea

Entry Island. South end of demoiselle range, lighthouse on summit.

Entry island. The road.

Entry island. Quaking bog or circular water hole overgrown with vegetation. Such solution pits are common between the demoiselles.

front beginning a section which extends continuously along the shore for more than two miles. This section practically ends at the east in a volcanic cliff known as Black Cape and as the same name has been applied to the post-town on the cliff, the section may be designated the *Black Cape section.*

When the late Doctor Ells and his aides mapped this part of the Gaspé peninsula the rocks on this stretch of shore were registered as part Siluric and part Devonic. Their variations in dip were recorded, but little clue was given to the stratigraphic and paleontologic importance of the peculiar development of the series.

It is well to record here, in passing, some recent determinations in the distribution of the paleozoic rocks in the New Richmond region in order to indicate the general condition in which the Siluric belt is involved. The plain between the rivers referred to is an elevated submarine or barachois bottom and is notable for its fine exposure of raised beaches on the sea front at New Richmond village, carrying shell banks which stand at a height of 20 feet and dip eastward about 3′ in a 100′. The shells, mostly lying vertical in the clay as they were lifted out of the sea, are: Mya arenaria, M. truncata, Macoma sabulosa, M. balthica, Saxicava rugosa, Seripes groenlandicus; and the gastropod Chrysodomus despectus.[1]

For a distance of five miles back from the sea front of this plain there are few, if any, rock exposures, but the Carleton mountains lie behind and about it in the form of an amphitheater, the nearer ridges of which are essentially composed of ledges of the red sandstone and conglomerates of the Bonaventure formation.[2] At the west, on the farther bank of the Grand Cascapedia gray unfossili-

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[1] Identified by Dr H. A. Pilsbry.

[2] Doctor Ells, in his maps of Gaspé and accompanying reports thereon, endeavored to subdivide the general mass of red sandstones and conglomerates which had been broadly grouped together by Logan under the name "Bonaventure formation," into a lower (Devonic) and upper (Carbonic) element. I believe entirely in Doctor Ells's close approximation to the facts in this expression of the value of the Bonaventure formation, but admit my conviction that an actual boundary between these elements can be located only with great uncertainty. It has been my practice to refer to the formation as a whole as of Devono-Carbonic equivalence and there is not, to my observation, any unconformity or change of sedimentation sufficient to justify a conception of discontinuity of sedimentation. Doubtless sections which I have not seen came under Ells's observation and I disavow any intention to discredit the determination of so admirable an observer as he. The truth is sufficiently stated in the admission of Devono-Carbonic age of

ferous limestones of Siluric age are exposed at various places about five miles from the mouth of the river and thence north. The tremendous unconformity between these highly inclined Siluric limestones and the essentially horizontal Bonaventure conglomerates is seen at every contact, but it is nowhere more forcibly pronounced than at the "Antimony mine" which lies seven miles back of New Richmond among the Carleton mountains. Here the unconformable formations mentioned have parted or been spread apart and the interval is filled by a "vein" or other deposit of quartz having a width of eight to twelve feet. Where best exposed this quartz carries a very considerable amount of diffused stibnite and along certain planes of the deposit the stibnite is concentrated into solid seams some of which are several inches in width and of notable extent. No trace of the Devonic in place has presented itself near these contacts surrounding the plain,[1] but among the loose pebbles and boulders which have been used in the construction of the Montgomery Company's breakwater at the west side of the New Richmond plain — material which has been gathered from the farm fields — are blocks of Devonic sandstone filled with Leptocoelia flabellites and Rensselaerias; the latter are unlike any species yet known from the Gaspé sandstone, but are allied to, probably identical with, species occurring in the Lower Devonic Moose River and Chapman sandstones of Maine and the Dalhousie beds of New Brunswick (cf R. atlantica and R. stewarti).

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these rocks. The Ells maps, for the reason intimated, become rather hard to read in the field because of the inclusion within the single Devonic color the lower part of these red beds with the other very different beds of earlier Devonic. To make Doctor Ells's conception of his Devonic unit clear in this place, his definition of the term as applied to his Gaspé maps is here given:

> The Devonian consists principally of moderately coarse gray conglomerates, sandstones and shales, though red beds occur at several places. The largest area is that of the Great Cascapedia which is probably continuous with that of the lower Restigouche, though largely concealed below Scaumenac bay by the red beds of the Lower Carboniferous. The beds of the Cascapedia though containing abundance of corals and brachiopods at several points have not so far yielded the rich flora and vertebrate fauna of the Campbellton and Scaumenac areas. This area is apparently separated from the more eastern or Gaspé area by ridges of Silurian and older rocks. The beds of Scaumenac bay and eastward probably represent the upper portion of the Devonian system, while those of Campbellton belong to its base.

[1] There are outcrops of dark shale with some gray sandstone on Brulé brook near the Little Cascapedia which Ells regarded as Devonic. No fossils have been found in them. The Siluric-Bonaventure contact noted above at the Antimony mine lies far within the Devonic area indicated by Ells's map, in fact not far from his Siluric-Devonic contact.

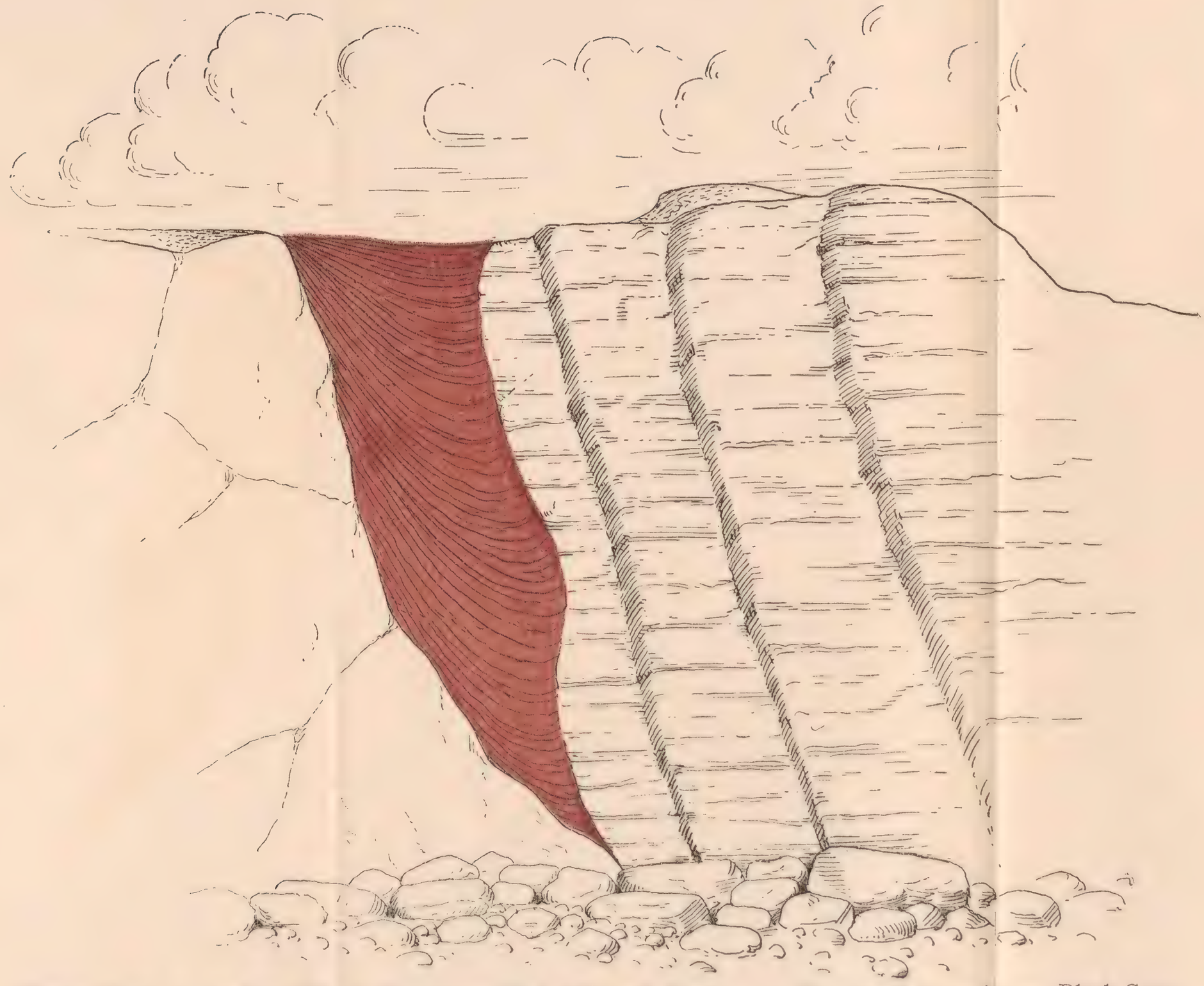
Fish remains similar to those of Scaumenac bay (Migouasha) twenty-five miles west, are reported to me by trappers as occurring about ten miles up the Grand Cascapedia, a statement I have no present means of verifying. In my judgment the brachiopods cited help to substantiate Doctor Ells's view that the Devonic basin here was separated by uplifts of earlier rocks from the Gaspé sandstone basin at the east and was probably continuous with the Devonic basin at the west carrying the Migouasha fish beds. In a previous paper I have pointed out the probable occurrence of the Lower Devonic in the Migouasha-Restigouche region with the species Cyrtodonta gratia and Schuchertella, while the Leptocoelia and Rensselaeria here mentioned indubitably point to its presence not far away.

The Siluric section now in consideration begins not far from the southeast angle of the mouth of the Little Cascapedia and, as already stated, continues without any material topographic break as far as Black cape, a distance of a little more than two miles along the bay shore. The rock strata are almost uniform in their upright attitude throughout their extent, pitched high with steep inclination for the most part to the south-southeast. Ells notes a variety of dips, some to the south-southwest and varying in angle from 40° to 75°; yet westerly dips are unusual and rather restricted in extent. This change in direction of strike is a deformation of slender magnitude. My inspection of the entire section is by no means a thorough one, but a watchful eye for suspected displacements and duplications has failed to detect any, and if such are present they are certainly veiled in parallel unconformities. Reappearances of strata of similar lithologic character are evident, but it is not certain that their fossils are alike. I desire to make all reservation necessary regarding possible duplication in the section, for the thickness of these Siluric beds, estimated apart from such possibilities, is very great, several thousand feet at all events. Yet it is well to recall in this connection that the Canadian geologists who have traversed the interior waterways of this great peninsula record the very great extent of the Silurians all through the region and inferentially their correspondingly great thickness. The upturned edges of these strata are ragged and much eroded. Though they are not here visibly overlain by the later deposits an open cleft on the face of the cliff near the middle of the section, three feet across and twenty feet high, is filled with fine red sandstone of Bonaventure age which has filtered in from above and lies now in oblique saucer-shaped layers, its color in striking contrast to the blue grays of the adjoining vertical limestones.

In describing this section we begin at its base near the east shore of the Little Cascapedia, for the position of the coral heads indicates that there has been inclination of the strata without overturn and that in accordance with this inclination the base of the section is at the west.

The lowest part of the rock section is on the front of the Pritchard property. The strata are greenish, highly nodular lime shales, very compact and heavy bedded, weathering out into irregular and gnarled shapes. These alternate with more highly calcareous shales and compact limestones of red and ochreous tints. These compact limestones contain Stricklandinias of great size (S. g a s p e n s i s Billings) and in great number. Often this brachiopod is as large as one's fist but it is usually crushed, except at the beaks. The original of Billings's species came from Siluric rocks at L'Anse à la Vieille which is a shore bay fifty miles eastward of this point. With these Stricklandinias are Spirifers of the S. n i a g a r e n s i s type and occasional Whitfieldellas. The rest of the fauna throughout the beds is largely stromatoporoids and corals. These are in enormous quantity and very considerable variety. The Stromatoporas vary from the size of a penny to immense masses. There are Halysites of several species, Favosites and Alveolites of great size, two to three feet in diameter, Heliolites of compact and branching forms, Zaphrentis and other cyathophylloids of large size, Syringopora and Eridophyllum in extensive colonies and various species. These corals are commanding for their size and abundance and are in admirable preservation. The fauna is essentially a coral plantation, lacking the features, however, of true reef construction. Additional species observed are Calymmene, Chonetes, A t r y p a r e t i c u l a r i s , Tentaculites, Diaphorostoma etc.

From here the section continues on eastward to the Howatson property. Beginning with the cliff exposure at Howatson's the section must be studied at low tide on account of the narrow beach. Here again the heavy calcareous highly nodular beds occur, varying in color from dark green, gray, yellow to red. All are blocky and heavy bedded except for thin intervals of shale between the limestones. The small nodules of irregular size weather loose freely and scatter over the beach. While there is great variety of lithologic expression in these beds in this respect they do not differ essentially from the Pritchard section, but their fauna is more profuse though the preservation is inferior. Silicification is extensive and where decay has been effective beneath the soil on top of the cliff, silicified fossils are set free.



Vertical cleft in the gray Siluric limestones filled with red Devonic or Bonaventure sandstone. Black Cape, Bay of Chaleur.

Stromatoporas, Heliolites and Favosites still abound; Cladopora and Trachypora are common, Camarotoechia like C. whitei and C. indianensis; Whitfieldella, Rafinesquina, Orthis, Atrypa reticularis (Niagara type), Calymmene, Orthoceras, Trochoceras etc. are present. About in the middle of this section occurs the infiltrated "vein" of red sandstone mentioned above, the surface of which can be traced in the fields overhead for two hundred feet away from the cliff.

From Howatson's the shore exposure continues without break into the Service and LeBlanc properties, the scraggy limestones maintaining their character as far as the little dock at Service's. Eastward from here follows a great thickness of gray sandstone, heavy bedded at first, thence passing upward into sandy shales. The sedimentation continues sandy to near the end of the section which terminates in the volcanic mass forming Black cape, but toward the top the sands become interlaminated with thin beds of volcanic ash, with red and purplish shale and eventually calcareous and variegated beds succeed, becoming in places compact limebanks entirely constituted of the debris of fossils. These abut against the volcanics of Black cape.

These sandstones and sandy shales are remarkably profuse in corals, some of the species, as of Halysites, palpably unlike those in the lower beds, but Halysites, Favosites, Heliolites, Syringopora and the stromatoporas of extraordinary variety and size occur together buried in this tremendous mass of sand. Plant remains, apparently fucoidal, are also present in the upper sands. The uppermost limestone banks are constituted of the debris of bryozoans and small corals which have been weathered out over extensive surfaces into exposures of much beauty and effectiveness; but other fossils than these are notably absent. The section on the whole is one well worthy of attention for its paleontology as well as its stratigraphy. The paleontologist would find at his hand unlimited quantity and variety of corals and stromatoporas, the museum collector fine demonstrative slabs and blocks and the stratigrapher a section of the Siluric apparently unexampled for its thickness and unusual composition. Leaving out of account repetitions of strata which thus far have not revealed themselves in structure or paleontology the entire section must approach a thickness of seven thousand feet. As far as the observed and collected fossils indicate the species are indirectly comparable to the later Niagaran of the interior basin, with an absence of the Clinton elements. The direct com-

parison in paleontology and paleogeography is doubtless to be made with the expressions of the Siluric afforded by the sections on Anticosti island and on the Arisaig shore of Nova Scotia. There is nothing in the Siluric sections of Gaspé elsewhere comparable to this, so far as my knowledge extends.

STRIKING UNCONFORMITY IN PALEOZOIC ROCKS AT LITTLE RIVER EAST, GASPÉ COUNTY

Little River East lies on the north shore of the Bay Chaleur just as it opens into the gulf. It is a small fishing hamlet about six miles west of Grand River. The unconformity here is of a sort that is general throughout the Gaspé peninsula where the upturned Siluric comes in direct contact with the Devono-Carbonic, but at this exposure it is so notable for its color contrasts as to attract attention of the traveler when steamer or sail happens to pass close enough inshore to bring it into clear view. The Little River is bounded on the west by a rock cliff reaching one hundred rods along the shore, and the base of the cliff is made up of light gray sharply stratified Siluric (Siluric-Ordovicic) thin limestones and hard shales standing at an almost vertical angle or dipping steeply toward the southwest: in this respect in conformity with the general attitude of the older paleozoics on all this coast. Over the very irregular edges of these lower beds lie the horizontal heavy-bedded masses of deep red Bonaventure conglomerate and sandstone, which has settled into all the surface irregularities of the gray Silurics. The section teaches again the well-known lesson of the exposure today of the Siluric rocks of this southerly Gaspé region during at least all the period of the early Devonic and its submergence in later Devonic to receive the rough water or continental deposits of the Bonaventure stage.

Little River East Gaspé — Unconformity between inclined Siluric strata and nearly horizontal Bonaventure conglomerate

NOTES ON DEVONIC FISHES FROM SCAUMENAC BAY, QUEBEC

BY L. HUSSAKOF

I An almost complete specimen of Coccosteus

Up to the present time Coccosteus has been known in America only from fragmentary remains. No specimen has been found showing the head with its associated armor plates, or with the notochord and dorsal fin. It is therefore of great interest to record the discovery recently of an almost complete specimen of Coccosteus canadensis — a species described by Dr A. S. Woodward,[1] in 1892, from a cranium. The specimen was collected for the New York State Museum, from the Upper Devonic shales on the shore of Scaumenac bay, near the village of Migouasha, Quebec. It came from a layer of thin-bedded shale at a level considerably below the massive, fine-grained sandstone containing the exquisitely preserved ferns made known by J. W. Dawson, and the splendid specimens of Bothriolepis with the soft structures and fins, described by Patten. The specimen was contained in a small slab of shale which had weathered out so that its upper surface lay exposed.

Description of specimen. The specimen consists of the head, a portion of the dorsal armor, several ventral plates, the impression of the notochordal region, some neural spines, and part of the dorsal fin. From its orientation on the slab, the animal appears to have become turned ventral side up after death, and to have settled into the sediment in that position. The head and dorsal armor were thus embedded in natural association, while the ventral plates, on the softer tissues loosening up, either had drifted out of their places (this is the case with the three plates seen in figure 1 to the right of the median axis of the specimen); or had fallen onto the dorso-median plate partly covering it. In collecting the fossil, the slab was unfortunately opened in such manner that most of the actual bone was lost and only the impressions (of the dorsal tuberculated surface) are shown in the rock.

Head. The head (CRAN) is 11½ centimeters long and shows, as impressions, most of the sutures and lateral lines. As it has already been well described by Woodward it is unnecessary to refer to it again in detail. To the left of the head is seen the right suborbital

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[1] A. S. Woodward. Further Contributions to Knowledge of the Devonian Fish-fauna of Canada. Geol. Mag., N. S., Dec. 3, 1892, IX, p. 481–85, pl. xiii.

(SO). It is represented by actual bone, shown in outer, ornamented, aspect. The body of the plate is deeper, that is, more nearly circular in outline, than its homologue in C. decipiens.

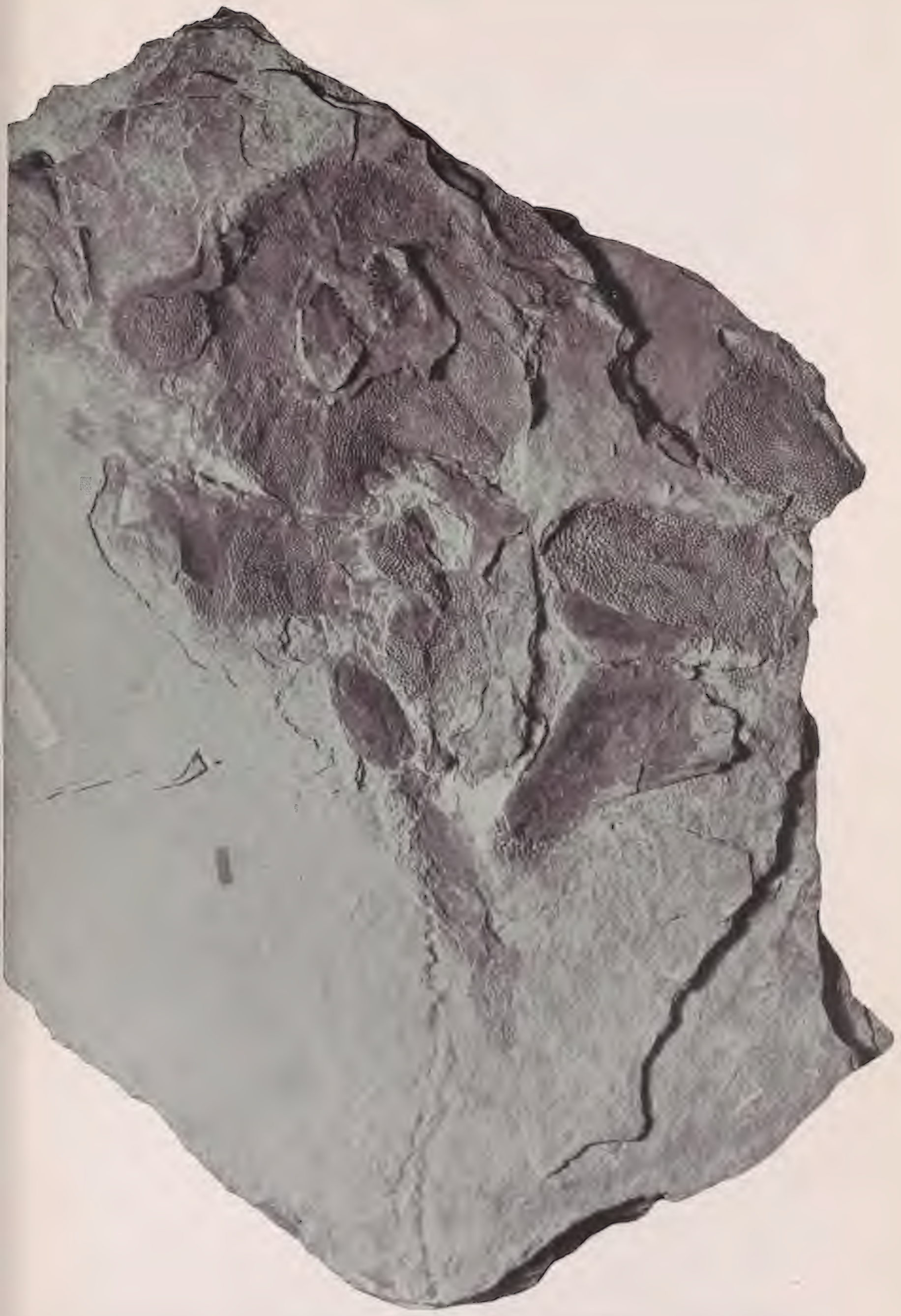
The present specimen throws light on one detail in the structure of the Arthrodire head. It is a moot question whether the so-called pineal canal, which is always seen on the inner aspect of the head of Arthrodira, perforated the bone and opened on the upper surface of the pineal plate. The state of preservation of the fossils has always left it open to doubt whether the pore on the upper surface had not been excavated by the collector while freeing the specimen from matrix. The present head of Coccosteus shows indubitably that the pineal canal did open on the upper surface of the head. For in the matrix, which is a cast of the upper surface, there is seen a small papilla (p) which is clearly due to the infiltration of sediment into the original opening on top of the head. The function of the canal is not known. But it may be inferred from its conical shape — seen especially in Dinichthys where, owing to its large size, it can be carefully studied — that it lodged a nerve organ which tapered to a point as it rose through the bone to the surface of the head. In the region of the external opening the surface of the cranium is either smooth, or tuberculated, like any other superficial bone, and not excavated for the reception of any sense organ, such as a pineal eye.

Mandibles. Portions of both mandibles (Mnd) are preserved. They show only the toothed portions of the elements, with small parts of the flattened posterior regions. There are seven teeth preserved in each mandible; they are like those in other Coccosteids — sharp, conical and slightly recurved.

Dorsal armor. The dorsomedian (DM) is 8½ centimeters long (excluding the process) and of the typical Coccosteid form. It exhibits the inner (under) surface and is largely covered over with fragments of other plates. I am not certain whether a posterior spine is present, since the hinder end of the plate does not show; but a keel is present, as is clearly indicated by the small part of it (k) preserved near the posterior end of the plate.

Only one antero-dorsolateral (ADL) is preserved, that of the right side. It retains its natural position with regard to the head and dorsomedian. Its lateral line is noteworthy since it consists of two branches which diverge at an acute angle a short distance back of the articulating process. A similar branched canal occurs on the anterior

Plate I



Coccosteus canadensis Whiteaves. Scaumenac Bay, Quebec.

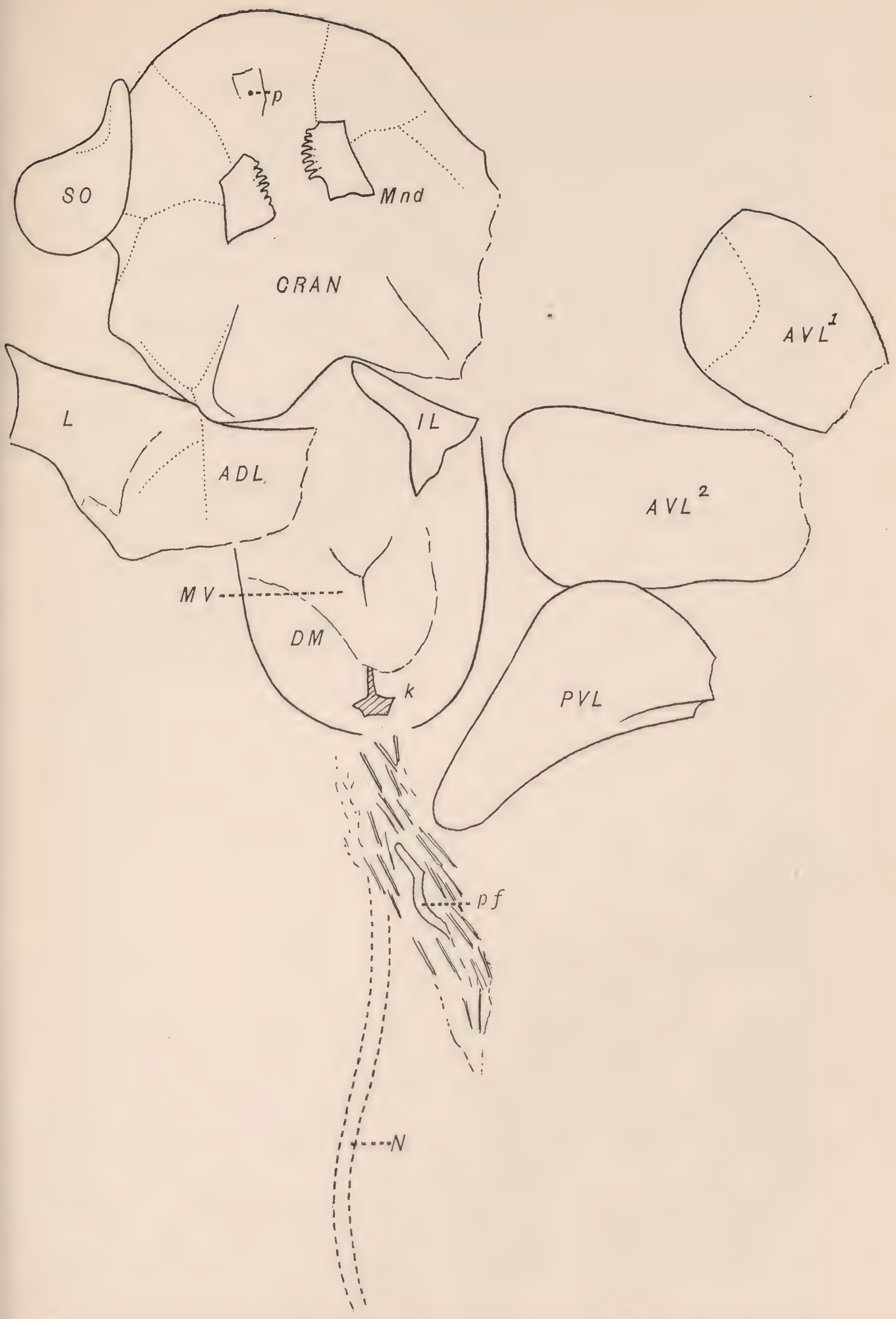


Fig. 1 Outline drawing of the specimen of Coccosteus canadensis Woodard, shown in plate 1.

ADL, anterior dorsolateral; AVL¹, AVL², anterior ventrolaterals; CRAN, cranium; DM, dorsomedian; IL, interlateral; k, "keel" of dorsomedian; L, lateral; Mnd, mandibles; MV, median ventral; N, impression of notochord; p, pineal opening; pf, "pelvic fin support"; PVL, posterior ventrolateral; SO, suborbital.

dorsolateral in some other coccosteids, for instance C. minor and C. magnus.

Neither of the posterior dorsolaterals is preserved.

Lateral plates. A lateral (L) and an interlateral (IL), both apparently belonging to the same side of the animal, are preserved. They are of the form usual in Coccosteids. They seem to be distinct plates and not, as might be expected by analogy with Dinichthys, the halves of a single plate.[1]

Ventral armor. The ventral plates are shifted from their natural positions and incompletely preserved. The antero-ventrolateral (AVL[1]) of the left side is preserved in outer aspect. It is relatively broad and characterized by the presence of a lateral line on its anterior third. The ornamentation on this plate is well preserved; it consists of small, blunt, conical tubercles with fine radiations at their bases.

The right postero-ventrolateral (PVL) is seen from the inner side; it is of the form usual in Coccosteus.

The median ventral (MV) is only partly preserved — in outer ornamented aspect. Its over-lapped flanges seem broader than common in Coccosteus — probably an adaptation for strengthening the ventral armor.

Notochordal region. This is shown here for the first time in an American coccosteid. Immediately behind the dorsomedian plate there is a group of neural spines and dorsal fin-rays, represented by their actual tissue. Back of these, extending a distance of 13 centimeters, to the end of the slab, there is a double series of impressions arranged in a gently sigmoid line. These correspond to neural and hemal arches and indicate the position of the notochord (N). Impressions of some neural spines are also clearly shown.

About 4 centimeters back of the dorsomedian there is a sickle-shaped rod (p.f) terminating posteriorly in what seems to be a broad plate, though this is either buried in the matrix or missing. This element I identify as one of the so-called "pelvic fin" supports, recently discussed in detail by Professor Dean.[2]

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[1] A discussion of these elements has recently been given by Burnett Smith. Notes on Some Little-known Fishes from the New York Devonian. Proc. Acad. Nat. Sciences Phila., Dec. 1910, p. 656–63.

[2] Bashford Dean. Studies on Fossil Fishes (Sharks, Chimœroids, and Arthrodires). Mem. Amer. Mus. Nat. Hist., IX, 1909, p. 282.

GENERAL CONCLUSIONS

Coccosteus canadensis is one of the largest species of the genus. It is distinguished from the best known species, C. decipiens of the Old Red Sandstone of Scotland, first, by its larger size, and second, by trivial differences in the shapes of several of its plates. It is quite close to Dinichthys halmodeus (Clarke) of the Marcellus shales of New York. Indeed the latter is very probably to be put back into the genus Coccosteus, in which Doctor Clarke had originally placed it;[1] for its supposed dinichthyid characters listed by Doctor Eastman,[2] when judged by our present knowledge of Coccosteus, are hardly enough to take it out of that genus. The mandibles, upon which Doctor Eastman chiefly based his opinion, seem to me typically coccosteid though poorly preserved. Moreover Dr Burnett Smith has recently shown[3] that in this species the laterals and interlaterals of each side are separate elements, as in Coccosteus, and not a single plate as in Dinichthys. From these facts it appears that Coccosteus halmodeus — not Dinichthys halmodeus — is the correct name of the Marcellus species.

The coccosteids hitherto recorded from North America are therefore the following:

1 Coccosteus occidentalis Newberry
2 " canadensis Woodward
3 " halmodeus Clarke
4 " macromus Cope
5 " cuyahogae Claypole
6 " (Protitanichthys) fossatus (Eastman)

Of these six C. canadensis is the one now represented by the best material.

II Note on a remarkable specimen of Eusthenopteron foordi

A remarkable specimen of Eusthenopteron foordi has lately been collected by Doctor Clarke in the type locality, Migouasha P. Q., Canada, and is preserved in the New York State Museum.

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[1] John M. Clarke. New or Rare Species of Fossils from the Horizon of the Livonia Salt Shaft. Thirteenth Ann. Rept. State Geologist, N.Y., 1893, p. 161–80, pl. i-iv.

[2] Devonic Fishes of the New York Formations. N.Y. State Mus. Memoir 10, 1907, p. 126. The synonomy of the species is given there also.

[3] Notes on Some Little-known Fishes from the New York Devonian. Proc. Acad. Nat. Sci. Phila., 1910, p. 661.

It represents a very large fish, perhaps the largest Eusthenopteron ever found, measuring nearly three feet in length, and at the same time shows nearly all the anatomical structures thus far made out in this species.

The accompanying figure gives a good idea of the specimen. The fish is seen from the left side, and is so oriented that the paired fins of both right and left sides are shown, while the caudal end is seen in profile. An important fact to be deduced from the appearance of the fossil is that Eusthenopteron was a more slender fish than the current textbook restoration, which we owe to Whiteaves, makes it appear. The depth of the fish in the region of the ventral fins can be accurately measured in the specimen; it is found to go over seven times into the total length (including tail). Hence the *maximum* depth of the fish must have been contained six or six and one-half times in the total length, not four and two-thirds as in Whiteaves's restoration. In other words, Eusthenopteron was shaped a good deal like Tristichopterus, its nearest allied form.

In the head region most of the cranial elements can be plainly made out. The opercular elements are separated from the shoulder girdle by a wide space, part of which no doubt represents the soft membrane back of the operculum. The operculum (Op) and the subopercular (S. Op) are clearly shown. The large plate, P. Op, probably comprises, as remarked by Traquair,[1] both a preoperculum and one or more cheek-plates; but the sutures separating these parts can not be clearly made out. The cleithrum (Cl) is broken off at its lower end; the piece I. Cl, is probably the infra-clavicle broken away from the cleithrum and shifted from its position. A gular plate (G), that of the left side, is beautifully preserved. There is no indication of lateral gulars in this specimen; but it should be recalled in this connection that Traquair found in a specimen in the Edinburgh Museum "the presence of five narrow lateral jugulars [i. e. gulars] very distinctly shown." The mandible (Mnd) apparently has sutures separating the dentary from one or more infradentaries, but they can not be plainly made out.

The fins are all present and are remarkable for the preservation of their internal cartilaginous supports. Those of the pectorals agree with the figure of these elements given by Woodward.[2] The ventral supports are not so well preserved; one can make out, how-

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[1] Traquair, R. H. Notes on the Devonian Fishes of Scaumenac Bay and Campbelltown in Canada. Geol. Mag., Decade 3, VII, 1890, p. 15–22.

[2] Woodward, A. S. Outlines of Vertebrate Palaeontology. 1898, figure 23.

ever, at the base of the fin, three small elements, parallel to one another, which are articulated proximally with one or two elements that can not be clearly made out on account of their crushed condition. These two rows of cartilaginous elements correspond respectively with the a-2 and a-3 series of the pelvic fin figured by Goodrich.[1]

Regarding the supports of the unpaired fins, those of the second dorsal (D^2) and of the anal (A) are beautifully shown. Their number, form and arrangement are already well known from Whiteaves's restoration. They are almost exact counterparts of each other. One point worth noting is that in the anal there seem to be only two instead of the three separate basilar rods found in the dorsal. The internal supports of the first dorsal (D^1) are also to some extent shown, although one can not make out the separate parts beyond what they are shown in the figure.

A feature of great interest in the specimen is the clearness with which the vertebral centra (V) are shown in the front half of the fish. The presence of vertebrae in Eusthenopteron has already been recorded by Traquair.[2] They extend only as far back as the first dorsal, behind which the notochord was apparently continuous, although neural and haemal spines were well developed. Twenty centra can be counted between the cleithrum (Cl) and the first dorsal fin. They are seen in profile so that one can not be certain whether they are complete rings or not. Each is about two and one-half times as high as wide, and provided with a neural spine. The haemal spines, if present in this region, are not shown. The centra are separated from one another by narrow spaces which increase backward until, near the end of the series, they are equal to the width of the vertebrae.

MEASUREMENTS OF THE SPECIMEN

Total length	2	feet	10	inches
Total length, allowing for missing tip of the tail	2	"	11	"
Head (to end of operculum)			7⅞	"
Depth across head (1 inch back of eye)			3¾	"
Depth in region of D^1			4¾	"
Depth between D^2 and anal			4	"
Gular plate, length (slightly restored)			5⅛	"
Gular plate, greatest width			1⅝	"
Greatest height of caudal fin			6¾	"

[1] Goodrich, E. S. On the Pelvic Girdle and Fin of *Eusthenopteron*. Quart. Jour. Microscop. Sci., N. S., XLV, p. 311–24, pl. xvi.

[2] Op. cit. p. 17.

III Notes on the anatomy of Scaumenacia curta

The New York State Musuem possesses a series of fourteen specimens of Scaumencia curta (Whiteaves), one of them more perfect than any other yet found, and the rest with one or another feature well preserved. Through the kindness of the Director of the Museum, this collection was recently placed in my hands for study. I have taken this ocasion also to go over the excellent materials, comprising some fifteen specimens, in the American Museum collection, and have also examined one fine, large specimen belonging to the Yale Museum.[1] These thirty odd specimens make up the largest assemblage of Scaumenacia ever brought together at one time, and afford excellent data for a reconstruction of the fish and for elucidating a number of anatomical details still imperfectly known. The specimens are all from the type locality — the Upper Devonic shales on Scaumenac bay, Quebec. A few are from the massive fine-grained sandstone in which the soft structures of Bothriolepis occur; the rest are from thin-bedded shales at a level considerably below this horizon.

Scaumenacia was first described by Whiteaves in 1881 [8]. He regarded it as belonging to the genus Phaneropleuron, and named it P. curtum. In 1887 [9] he discussed the anatomy of this fish and figured one of the types and several anatomical details — cranial plates, dentition and scales. These confirmed him in his original opinion that the fish was a dipnoan. In 1889 [10] he published a "slightly restored" figure of the fish.

In 1893 Traquair [7] pointed out that this fish differed from Phaneropleuron in having two dorsals instead of one. He therefore regarded it as a distinct genus for which he proposed the name Scaumenacia.

Two restorations of Scaumenacia have been published, one by Whiteaves (mentioned above), the other by Traquair, in Dollo's paper "Sur la Phylogénie des Dipneustes" [1]. Several anatomical features, in addition to those by Whiteaves mentioned above, have also been figured: a dental plate (Jaekel [4]); the head (Eastman [2]); and the anal fin (Woodward [11]).

Size. Most of the specimens of Scaumenacia are small, under 10 inches in length, giving the impression of a rather small fish.

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[1] This specimen was kindly lent me for study by Professor R. S. Lull.

Scaumenacia curta (Whiteaves). Upper Devonic, Scaumenac Bay, Quebec.

Remains of larger fish are, however, known. A specimen in the American Museum lacking part of the tail measures 14½ inches, and when complete must have been 18 inches in length. Another large fish, no. 2875 Yale Museum, is about 15 inches long. Hence Scaumenacia may be regarded as having reached a length of at least 18 inches; in other words to have been as large, full grown, as a medium sized Neoceratodus.

Restoration. The accompanying restoration (figure 3) is based on a beautiful specimen in the New York State Museum. This is a fish eight inches long in a nodule of fine-grained sandstone (plate 2). It is almost uncrushed, which is an important circumstance, for Scaumenacia specimens are usually badly distorted through lateral pressure so that the fish appears much deeper than it must have been in life. This specimen shows all the fins save the caudal, which is nearly all missing. But this fin, fortunately, is beautifully preserved in another specimen of the same size (7661 American Museum). The State Museum specimen also shows the scales so that their size and imbrication can be clearly seen on the greater part of the fish.

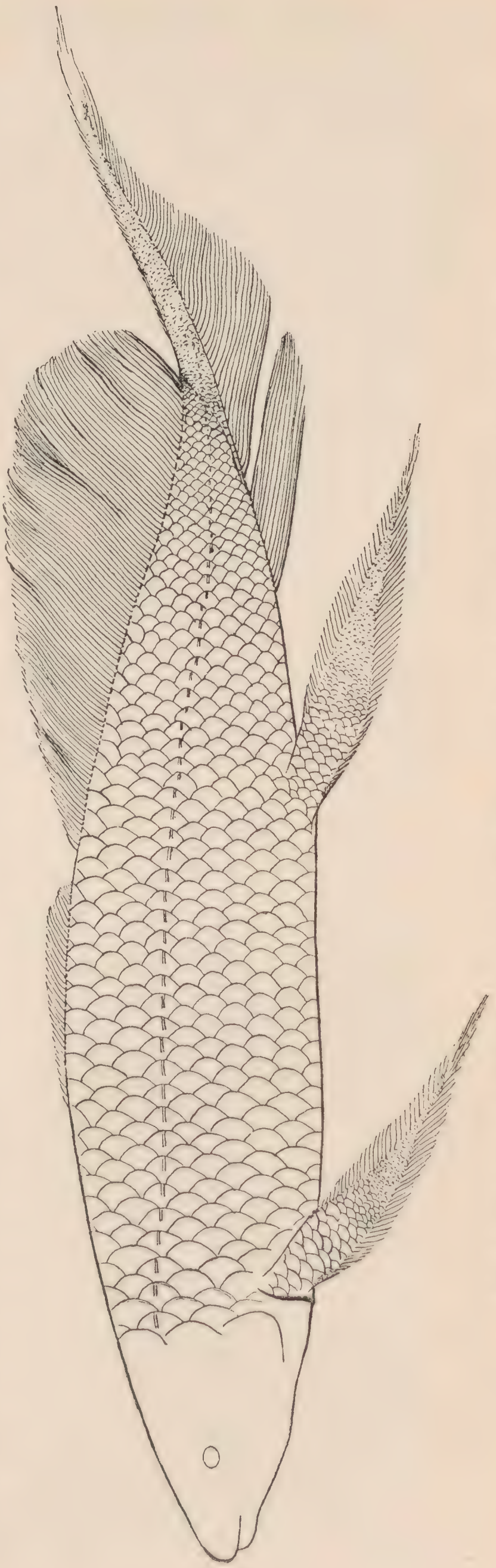

Fig. 3 Restoration of Scaumenacia curta (Whiteaves). Upper Devonic. Scaumenac bay, Quebec, Can.

The distinctive features of Scaumenacia may be summarized as follows:

Body-form gracefully fusiform, about as much compressed as Neoceratodus. Maximum depth equal to head, and contained six times in total length (including caudal). Fins well developed; paired fins archipterygia, large and relatively slender, with scaled central portion and divergent marginal dermal rays. Length of pectoral one and one-third times the maximum depth of body; when adpressed to body extending over two-thirds the distance from origin of pectoral to origin of ventral. Ventral longer and somewhat broader than pectoral, about one and one-half times the maximum depth of body; commencing slightly back of origin of second dorsal. First dorsal very low, its maximum height one-seventh or one-eighth its length; commencing considerably back of occiput, but somewhat nearer to origin of pectoral than that of ventral. Space between dorsals one-seventh the length of first dorsal. Second dorsal very much higher than first, its maximum height two-thirds the maximum depth of fish. Caudal strongly heterocercal. Anal relatively small, situated close to lower lobe of caudal. Lateral line present.

Cranium. Three specimens (2875 Yale Museum; 7656 and 7677 American Museum) in the materials in hand, show the cranium in fair preservation. Figure 4 is based on these, more especially on the Yale specimen. The arrangement of the cranial elements is quite like that in Phaneropleuron as figured by Goodrich [3, p. 239]. There is a median supra-temporal (MS), preceded by a pair of parietals (Pa), and anterior to these a pair of frontals (Fr). The suture between the frontals is rather vague in the Yale specimen, but it is very clearly shown in an American Museum specimen (7677). There are also a number of other paired plates arranged symmetrically on either side — pterotics (Pter), supraorbitals (Su. O), and several others whose homology is not quite clear. The rostral region is lacking in all the specimens in hand and is indicated in the figure by analogy with other dipterine crania.

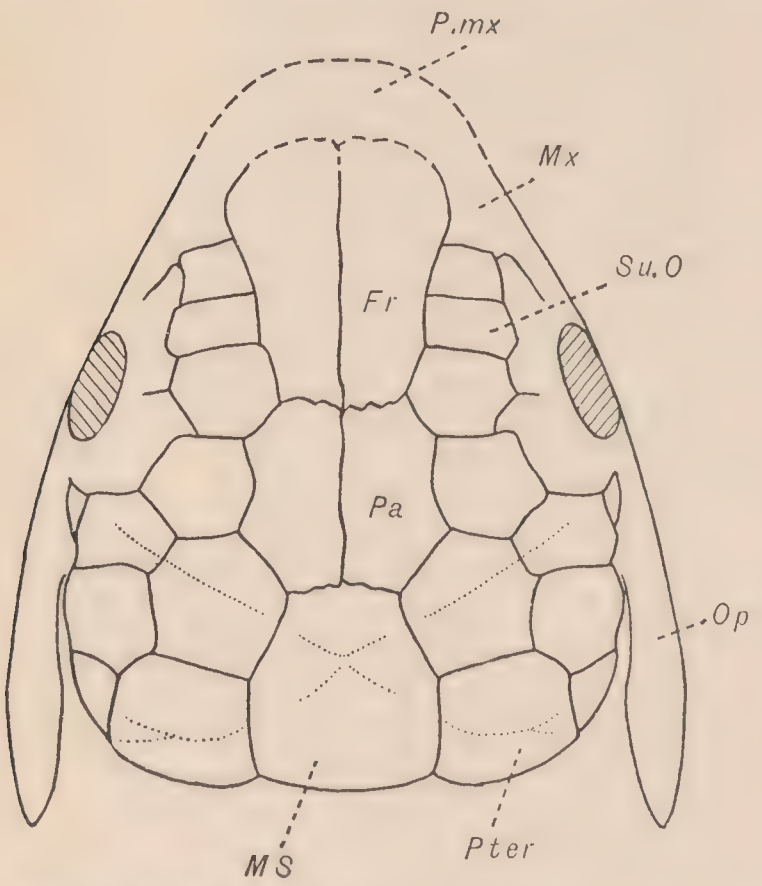

Fig. 4 Head of Scaumenacia curta (Whiteaves). Fr, frontal; MS, median occipital; Mx, maxilla; Op, operculum; Pa, parietal; P. mx, premaxilla; Pter, pterotic; Su. O, supraorbitals.

Scaumenacia curta (Whiteaves). Nearly complete fish showing especially well the caudal half — Upper Devonic, Scaumenac Bay, Quebec.

Dentition. It is well established that Scaumenacia had typical dipnoan dental plates. Whiteaves [9] figured a portion of such a plate showing a group of pointed denticles arranged in rows; and Jaekel [4] has given a figure of a complete lower dental plate.

Figure 5-b represents an upper, or palato-pterygoid, dental plate drawn from a small specimen in the American Museum collection (7662). This plate and the one figured by Jaekel show plainly that Scaumenacia had a Dipterus-like dentition. The dental plate shows seven rows of small pointed and slightly compressed denticles. The rows do not radiate from a common point but from a smooth area near the inner angle of the tooth. The number of denticles in a row varies from two or three in the innermost, to seven or eight in the outermost row.

Fig. 5 Scaumenacia curta (Whiteaves); dental plates and scale. *a*, vomerine teeth; *b*, palato-pterygoid dental plate; *c*, portion of a scale, showing ornamentation (enlarged)

Besides a dipterine plate I have found vomerine teeth in Scaumenacia (figure 5-a). These are of great importance considering the rarity of specimens of these teeth in the extinct dipnoans. They were found in their natural position in a large fish in the American Museum (no. 7656). When collecting the specimen in the field it was accidentally struck so that the snout broke off as a small fragment. On the inner surface of this, and right in advance of the most anterior denticles of the upper and lower dental plates, could be seen, above, a pair of small, thin vomerine plates (figure 5-a). They are broader than deep, with the lower edge cut into four unequal, sharp teeth or serrations. In view of this serrated condition the vomerines of Scaumenacia may be regarded as more primitive than those of the adult Neoceratodus. They resemble somewhat the vomerines of the embryonic Neoceratodus as described by Semon [5]. The small fragment of matrix containing these teeth was unfortunately lost; not, however, before a careful figure of the vomerines had been prepared.

Scales and lateral line. Regarding the scales, Whiteaves wrote [9, p. 108]: "Scales thin, cycloid, imbricating with exposed surfaces concentrically striated and marked also with exceedingly minute radiating lines, which latter are only visible under a somewhat powerful lens." The superficial ornament of the scales is indeed

exceedingly fine. It is very generally worn off so that it is hard to find a specimen showing it. On several scales in the specimen belonging to the Yale Museum (2875) it is well shown and from one of these figure 5-c was drawn. The ornament consists of exceedingly fine lines, several of which may flow together towards the center of the scale into an elongate irregular elevation. From this area the lines are given off at irregular intervals and may again fuse here and there for part of their length. They may be traced to the posterior border of the scale.

The lateral line Scaumenacia has not yet been figured, although it is known to be present in this form. It is here figured in a small specimen three and one-quarter inches long, in the New York State Museum, in which it is beautifully preserved.

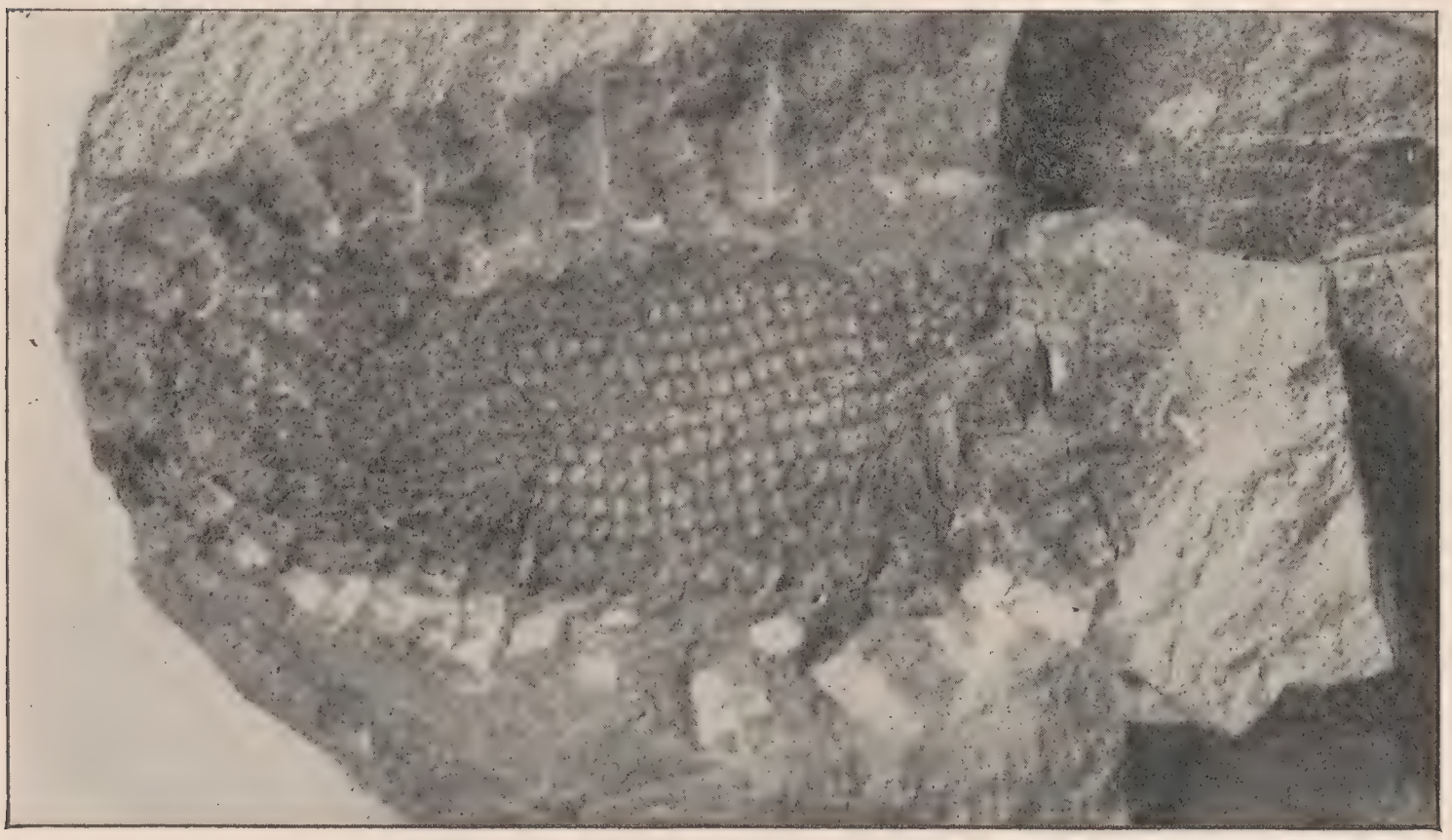

Fig. 6 Scaumenacia curta (Whiteaves). Small specimen, 3¼ inches in length, showing ateral line; natural size. Upper Devonic. Scaumenac bay, Quebec, Can.

LITERATURE CITED

1 **Dollo, Louis.** 1895. Sur la phylogénie des dipneustes. Bull. Soc. Belge de Géol., IX, p. 79–128, pls. v-x. [Pl. v, fig. 6, is an outline restoration of *Scaumenacia curta,* labeled "Figure original de M. R. H. Traquair."]

2 **Eastman, C. R.** 1908. Devonian fishes of Iowa. Am. Rep't Iowa Geol. Surv. XVIII. [Figure of head of Scaumenacia. Fig. 35.]

3 **Goodrich, E. S.** 1909. Vertebrata craniata (First fascicle: Cyclostomes and Fishes). Lankester's "A treatise on zoology." Part IX.

4 **Jaekel, O.** 1890. [On *Phaneropleuron* and *Hemictenodus,* n. gen.] Sitzber. Gesell. naturforsch. Freunde Berlin. p. (1–8).

5 **Semon, R.** 1899. Die Zahnentwickelung des *Ceratodus forsteri.* Zool. Forsch. in Austral. u. Malay Archipel. p. 115–35, pls. xviii–xx.

6 **Traquair, R. H.** 1890. Notes on the Devonian fishes of Scaumenac Bay and Campbelltown in Canada. Geol. Mag., n. s., Dec. iii, VII, p. 15–22.

7 ————————. 1893. Do. No. 3. Geol. Mag., n. s., Dec. iii, X, p. 262–67.

8 **Whiteaves, J. F.** 1881. On some remarkable fossil fishes from the Devonian rocks of Scaumenac Bay, P. Q., with descriptions of a new genus and three new species. Canadian Naturalist, n. s., X, p. 27–35.

9 ————————. 1887. Illustrations of the fossil fishes of the Devonian rocks of Canada. Part I, Trans. Royal Soc. Canada, IV, p. 101–10, pl. vi-x.

10 ————————. 1889. Do. Part II. Trans. Royal Soc. Canada, VI, p. 77–96, pl. v-x.

11 **Woodward, A. S.** 1893. Note on a case of subdivision of the median fin in a dipnoan fish. Annals and Mag. Nat. Hist., ser. 6, XI, p. 241–42, figure

NOTE ON A SPECIMEN OF PLECTOCERAS JASON (BILLINGS)

(With one plate)

BY RUDOLF RUEDEMANN

Preparations for the moving of the State Museum to the new Education Building brought to light a block of middle Chazy limestone from Valcour, Clinton county, N. Y., collected by Professor van Ingen and the writer, which had not been at hand when the Cephalopoda of the Beekmantown and Chazy formations of the Champlain Basin were described by the writer (N. Y. State Mus. Bull. 90, 1906), but which is so much superior in perfection of shell and in size to the specimens used for that paper that we are sure the publication of its figure will be an addition to our knowledge of the form. Above all it shows the entire living chamber and the apertural margin, both not observed before, as far as we are aware.

The living chamber attains in length a little more than one-third of a volution. It is entirely free and furnished in the specimen with very strong costae except near the aperture where the ribs cease rather abruptly. The aperture is directed as it had been described from the growth lines in the above-mentioned paper.

We have drawn in the nepionic and neanic portions observed in another specimen and figured in longitudinal section in the former publication,[1] thus obtaining a view of the entire specimen. The rate of growth of the conch is thereby distinctly shown.

The uncoiled condition of the entire living chamber and the disappearance of the ribs near the aperture suggest that the specimen had attained mature if not gerontic age, and the shell therefore represents the full size of this species.

The septate portion of the whorl here represented is exfoliated and therefore, while showing the septa, fails to show the costae which are much closer in the neanic shell. The surface of this portion is represented in Bulletin 90, plate 29, and indicated in the restored part. The living chamber is also largely exfoliated and only shown in its interior cast and the smoother character of the apertural portion may be largely due to this state of preservation. The last portion of the apertural chamber would then seem to have possessed a thicker wall. On account of the absence of the shell, the conch now also appears more evolute than it was in reality.

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[1] Text figure 44, page 485. The figure is in natural size, and not X ¾ as erroneously marked.

The depth of the cameras increases but little in the specimen and they remain relatively shallow as they had been found to be in the smaller specimens; the lateral lobe of the later sutures is apparently a little higher than in the earlier ones.

The species was cited in Bulletin 90 as coming from the lower Chazy of the Valcour section. The specimens described had been obtained by Professor van Ingen and the writer in the beds outcropping along the shore of Lake Champlain north of Valcour (Sibley's) dock. These beds were in preceding publications referred to the lower Chazy on lithologic grounds but fossil lists since published by P. E. Raymond (Annals of the Carnegie Mus., vol. 3, No. 4) show that they belong with the middle Chazy (see op. cit. p. 574). Doctor Raymond cites P. jason from B120 (op. cit. p. 535), i. e. the beds just across the bay north of Sibley's dock; B124, the rocks at lake level on the shore at Day's Point; and his station B128, exposures in the large quarries near the road between Valcour and Day's Point. Our records show the species to have been found in beds approximately corresponding to Raymond's stations between these two points. In all the stations where it has been found it is associated with faunas which, although lacking the Maclurites magnus, are of middle Chazy aspect, the beds in the quarries representing Raymond's zone 2a or the Malocystites murchisoni zone of his division 2 (middle Chazy). If Plectoceras jason is here a middle and possibly upper Chazy form, its range agrees with that observed in its type locality, the Mingan islands.

Plectoceras jason (Billings). Natural size
Chazy limestone, Valcour, N. Y.

ON THE GENESIS OF THE PYRITE DEPOSITS OF ST LAWRENCE COUNTY

BY C. H. SMYTH, JR

In an effort to get some clue to the methods of formation of the pyrite deposits of St Lawrence county, which in recent years have been more extensively worked than before, the important mines and several pits and prospects were visited and examined with such care as limited time and the conditions of the workings permitted. The expectation, based upon previous knowledge of the geology of the region, that the problem would prove a troublesome one to solve was fully justified by the result. A thoroughly satisfactory investigation of the matter can be carried through only after the general geology of the region is worked out in detail, but as this consummation is doubtless remote, a statement of the results of the present study seems warranted.

The most important workings are the mine on the Cole farm, four miles northeast of Gouverneur, the Stella mines, one mile north of Hermon, and the group of mines at Pyrites, or High Falls, on the Grasse river, six miles south of Canton. Besides these there are many smaller mines and prospects scattered over this part of the county and, as the geological conditions which favor the formation of the pyrite deposits prevail over a large area, it is probable that many occurrences have escaped notice.

GENERAL GEOLOGY

The geology of the region is exceedingly complex and, for the most part, as yet unstudied in detail; but, speaking in most general terms, there is an older series of highly metamorphosed sediments, crystalline limestones, gneisses, schists and quartzites, classed as Grenville, cut by igneous rocks of varying character and age, but chiefly granites, which are generally gneissoid. More basic rocks, diorites and gabbros, are not lacking but, particularly as regards the latter, are much less important than farther south, in the heart of the Adirondack region.

The typical rocks of either class, sedimentary or igneous, are of course readily distinguished, but in many cases extreme metamorphism has completely obscured the original character, making a positive determination difficult or even impossible. It often happens, too, that a rock is of composite character as a result of injection or assimilation, giving, on the one hand, a sediment more or less

"soaked" with igneous material and on the other an igneous rock which has melted into itself or assimilated sedimentary material. Between these two types every gradation exists, thus introducing added complication and uncertainty.

The pyrite deposits occur in association with the sedimentary rocks, although it is probable that they are more or less closely dependent upon the igneous rocks for their existence.

Throughout the Grenville series pyrite is a rather common accessory mineral and becomes particularly conspicuous in the so-called "rusty gneisses" which frequently occur. These rusty gneisses owe their name to the dark iron stain resulting from the weathering of pyrite, which is often present in large amounts. The question of the true nature and origin of the rusty gneisses is most intimately connected with that of the pyrite deposits, which in many, if not all, cases are merely exceptionally pyritiferous varieties of these rocks, or of rocks closely associated with them. At the very outset this makes the problem in hand difficult, since it necessitates the determination of the character of a widespread group of rocks which, though superficially similar, vary in character rather widely and may be of quite diverse origin in different cases.

In dealing with the Grenville one is on safe ground in classing the crystalline limestones and quartzites as metamorphosed sediments, but with reference to the schists and gneisses the case is quite different. While many of these may with confidence be regarded as metamorphosed shales or impure sandstones and limestones, others are beyond question intrusive sheets and dikes, while it is possible that some may originally have been contemporaneous lava flows and tuffs, though no case of the latter kind has yet been established. Thus while the rusty gneisses appear as part of the Grenville series, it does not necessarily follow that they are of sedimentary origin, though it has become rather habitual to take this view of them. That this course is in general justified seems probable from the fact that these rocks are strongly banded, exceedingly variable in composition, and so far as studied not closely related in composition to any of the well-established types of igneous rocks. It must be admitted, however, that some examples, marked by the presence of scapolite replacing plagioclase, closely resemble certain varieties of gabbro.[1]

If all of these pyritiferous rocks could be regarded as representing metamorphosed gabbros, a simple solution of the whole problem

[1] Smyth, C. H. jr, Trans. N.Y. Acad. Sci., XII, 1893, p. 215–17.

would be suggested, the pyrite being a probable primary constituent, concentrated by magmatic differentiation. As shown below, this explanation is, at first glance, strongly suggested for one of the chief deposits but further study indicates that it is inapplicable even here, while as a general explanation of the rusty gneisses it has no claim to consideration.

For the present it may be assumed that the rusty gneisses are of sedimentary origin, representing shales and sandstones interbedded with the limestones of the Grenville sea.

With this brief introduction, the different mining localities may be described, taking them in order from west to east, and in each case first stating the facts observed in the field and then giving the leading megascopic and microscopic features of typical specimens of ores and wall rock. The paper closes with a general discussion of the problem of genesis.

THE COLE MINE

The Cole mine, situated about four miles north of Gouverneur, was idle when visited by the writer, but has since been started up again and is likely to be an important producer. Rock exposures around the flooded pit were not extensive but sufficient to show the usual strongly foliated rusty gneisses, the more pyritiferous parts of which constitute the ore. Beneath this is a mica schist, and still lower down, with a gap of five or six hundred feet in outcrops, is a beautiful serpentinous limestone. Thus the rocks are distinctively Grenville in type and, as a matter of fact, the location is in the midst of one of the most extensive of the Grenville limestone belts of the region. The only recognizable igneous rock associated with the ore is pegmatite which occurs in small patches and strings, particularly in the underlying mica schist. All of the rocks present, including the pegmatite, contain some pyrite, and here as elsewhere the ore body is merely that part of the gneiss and schist formation in which the amount of pyrite is particularly large.

The pyrite is very irregularly distributed, appearing in streaks, bunches and veins (figure 1).[1] As the mineral increases in amount these irregular masses blend and form large and rich ore bodies, in which the relation of the pyrite to the rock is wholly obscured. But in the leaner ore the pyrite appears distinctly, so far as its present distribution is concerned, to be of vein origin for, while commonly running parallel to the banding of the rocks, it

[1] For all the photographs in this paper the writer is indebted to the kindness and skill of Professor Gilbert van Ingen.

repeatedly cuts across at all angles and wanders about quite independently. Thus it is evident that at least a part of the pyrite has been deposited in its present position quite late in the history of the formation. The pyrite ranges from tiny scattered grains up to large masses, and may be irregular in shape or bounded by its own crystal faces. Crystals an inch or more in diameter are common, not in cavities but wholly imbedded in the country rock.

Intimately associated with the pyrite is graphite in sufficient abundance to be conspicuous in the tailings from the separator.

While the gangue is ordinarily the normal country rocks, the dump affords many lumps of quartz whose relations to the ore and other rocks are not shown in the flooded pit. This material appears to be vein quartz, in spite of its carrying considerable graphite.

The ore body is perhaps ten feet thick as an average and conforms in a general way with the strike and dip of the surrounding rocks. That the latter are, with the exception of the pegmatite before mentioned, apparently sedimentary in origin is the most striking fact exhibited at this locality with reference to the origin of the pyrite deposits in general.

While the sedimentary character of the immediately adjacent rocks is apparent, it must not be overlooked that everywhere the Grenville is cut by intrusives which, in this vicinity, are abundantly represented by the white granite which is the common phase of the granite-gneiss when intrusive in limestone. With these intrusions, the pegmatite associated with the pyrite must be connected, and quite possibly too the quartz mentioned above, in spite of its graphite, the latter mineral being frequent and sometimes abundant in very acid pegmatites elsewhere associated with pyrite. A quarter of a mile south of the mine the crystalline limestone contains large quantities of quartz, probably of vein origin, but quite free from both pyrite and graphite.

Passing to the more detailed features of the deposits we find a fine-grained, gray banded schist of the wall containing considerable scattered pyrite strung out parallel to the foliation, while a minor cross fracture is filled with calcite and a little pyrite, the latter permeating the wall of the fissure and thus showing a very late circulation of pyrite in the rock. A thin section shows abundant quartz, kaolinized feldspar, chloritized mica, some sericite and graphite. There are also many grains of colorless tourmalin. Pyrite, in moderate amount, occurs in crystals and rodlike and branched aggregates, which run between and very commonly project into the other minerals as shown in figure 3. Sometimes pyrite separates and

Fig. 1 Lean ore, Cole mine, showing large, irregular masses of pyrite in the fine-grained rock. (9/10 natural size)

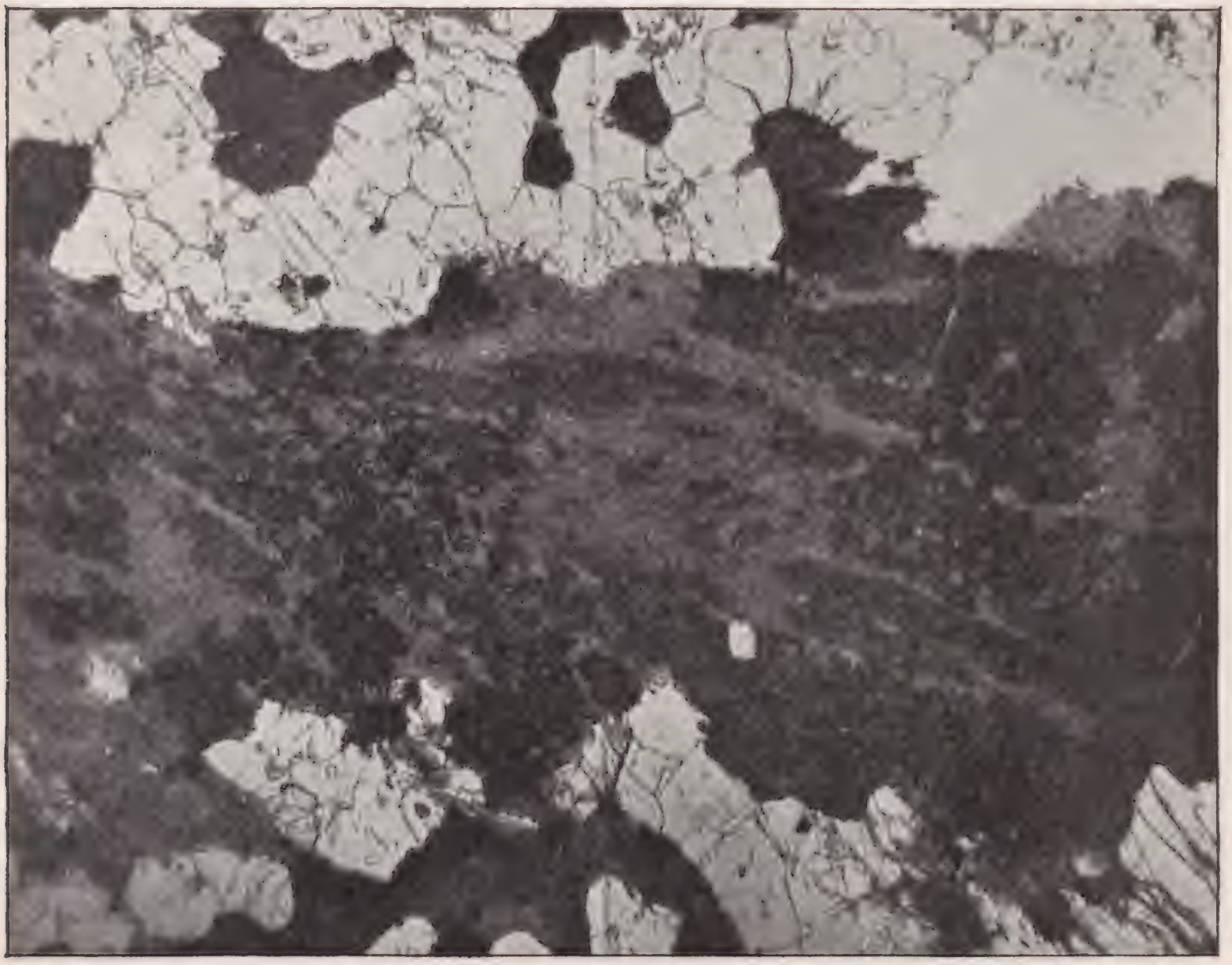

Fig. 2 Photomicrograph of schistose wall-rock, Cole mine, with pyrite developed in a chlorite vein and, to a less extent, throughout the rock. The white mineral is almost entirely quartz. Some cataclastic structure is shown. (Magnified 27.5 diameters)

entirely incloses adjacent areas of quartz in perfect optical continuity, thus clearly showing a replacement of quartz with no mechanical disturbance. Two large grains of pyrite with small branches attached suggest very strongly an older generation with a younger growing upon it. This phenomenon is worthy of special note in this case since it is very exceptional in the material examined.

That the pyrite has crystallized after the other minerals is obvious and there can be no doubt that it has replaced an equivalent amount, not only of chlorite, but of the much more stable and resistant quartz.

A similar rock, but rather more massive, contains a much larger amount of pyrite in large bunches connected by stringers and veinlets. Thus to the unaided eye the pyrite appears to be secondary, while as there is nothing to suggest preexistant cavities other than minute cracks it seems equally clear that it must be a replacement. In thin sections the rock is similar to the last but has little tourmalin, is decidedly kataclastic and has more chloritic alteration. Pyrite is much more abundant in scattered grains, rods and branching aggregates, commonly in association with chlorite, while the section is traversed by a vein of chlorite in which the abundant pyrite ranges from large solid masses to rods and shreds that might almost be called fibrous (figure 2).

The greenish chloritic alteration runs all through the section in the spaces between cracked quartz grains, at whose expense it seems to have developed. Considerable sericite is present, appearing as tufts and shreds in quartz and chlorite, after which it is secondary. It also forms narrow veins around, and fills cracks in, many of the pyrite masses, indicating that the sericite is at least in part younger than the pyrite. Thus the microscopic evidence agrees with that obtained by the naked eye in pointing to a secondary origin for the pyrite, replacing the original minerals which also show pronounced chloritization.

A specimen of rich ore very similar to ores at other mines is a medium grained, dark rock with abundant pyrite unevenly disseminated through it in crystals and irregular grains and sometimes in large masses, like those in the preceding specimens. The dark color of the rock is largely due to fine scales of graphite, which are exceedingly abundant. A thin section shows a large amount of quartz, little orthoclase and no plagioclase. Muscovite, in part at least secondary, is fairly abundant. There is much pale green, nearly or quite isotropic chloritic alteration product, and abundant graphite. The roughly equidimensional grains of pyrite give little

hint of their origin or relation to other minerals except that occasionally they seem to be molded upon the mica.

The rusty gneiss underlying the ore is strongly foliated and in hand specimens shows abundant mica, quartz, some pyrite and garnet. Thin sections show quartz, muscovite, bleached and altered biotite, much garnet and chlorite, little or no graphite, and considerable pyrite. The latter is sometimes molded upon other minerals as in figure 4.

In chlorite there is sometimes a very free growth of pyrite, as shown in figure 5.

From these facts it is apparent that the pyrite has crystallized in its present position after all the other minerals, including the secondary chlorite but excepting sericite, were formed. This of course makes the deposition of the pyrite subsequent to the metamorphism which converted the Grenville sediment into the existing gneiss, since the chlorite in which the pyrite has grown is an alteration product of the metamorphic minerals. This is an important step toward determining the origin of the deposits if it can be proved that the foregoing relations are not simply the result of circulation and recrystallization of pyrite already present in the rock long before this final precipitation.

THE HENDRICKS MINE

About two miles northeast of the Cole mine, on the Hendricks farm, are some small openings of pyrite which have never got beyond the stage of prospects, but are nevertheless of interest in their bearing upon the problem of genesis. Here again, as at the Cole mine, the pyrite deposits lie in the midst of Grenville rocks with no large masses of igneous rocks near by. The pyrite is near the bottom of a heavy body of fine, strongly laminated Grenville gneiss, the ore being simply a pyritous and therefore "rusty" part of the formation. This gneiss makes a high ridge north of the mine,

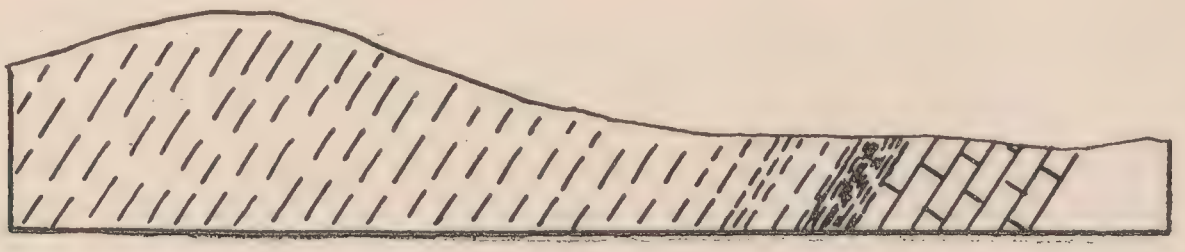

Fig. 6 Rusty gneiss and ore shown by heavier shading

while to the south there is a wide gap in outcrops except for some fifty feet of typical limestone almost immediately beneath the ore. The section is diagrammatically represented with little reference to scale in figure 6.

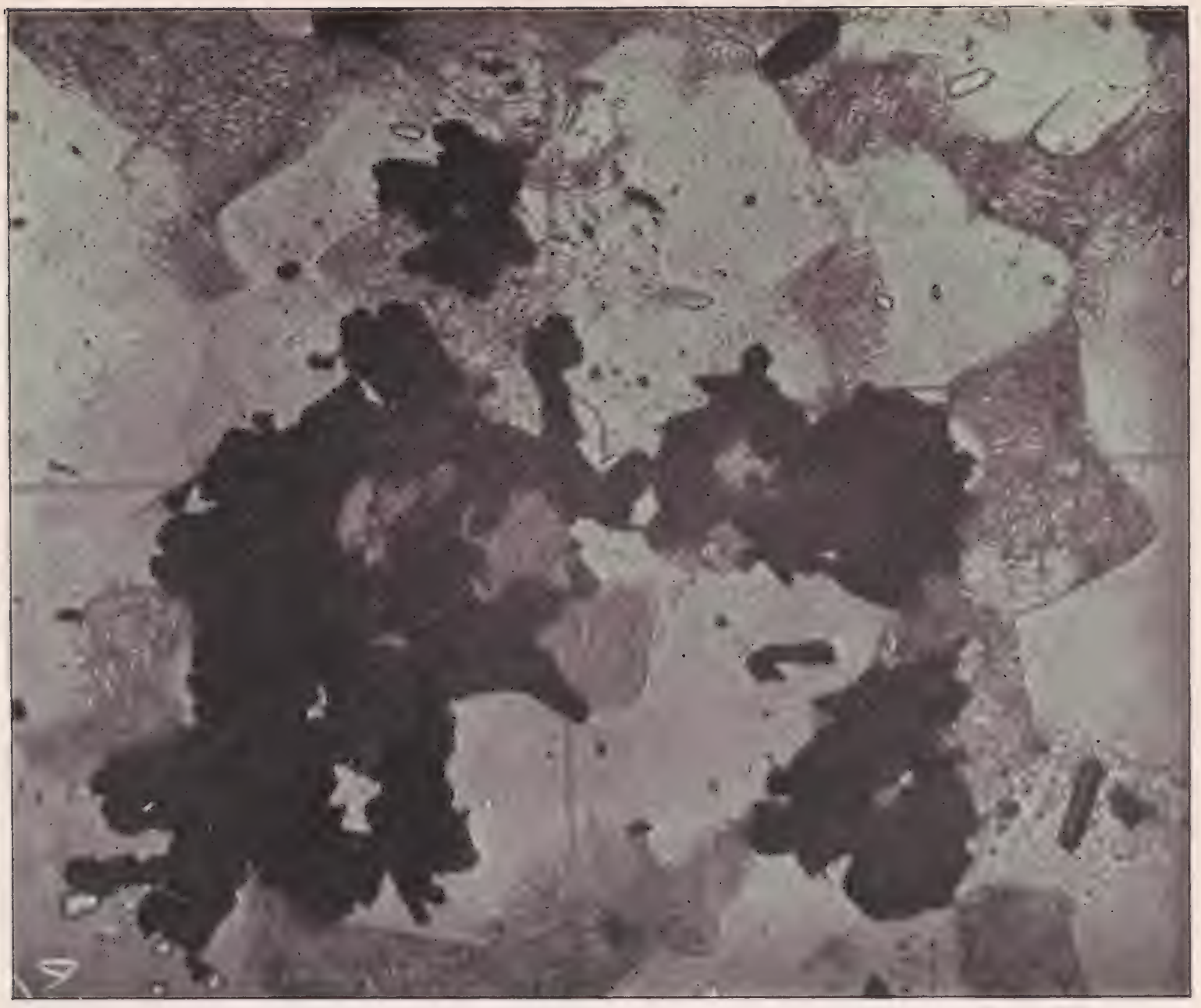

Fig. 3 Photomicrograph of fine-grained schistose wall-rock, Cole mine, with branching masses of pyrite, and quartz, sericite, chlorite and tourmalin. (Magnified 154 diameters)

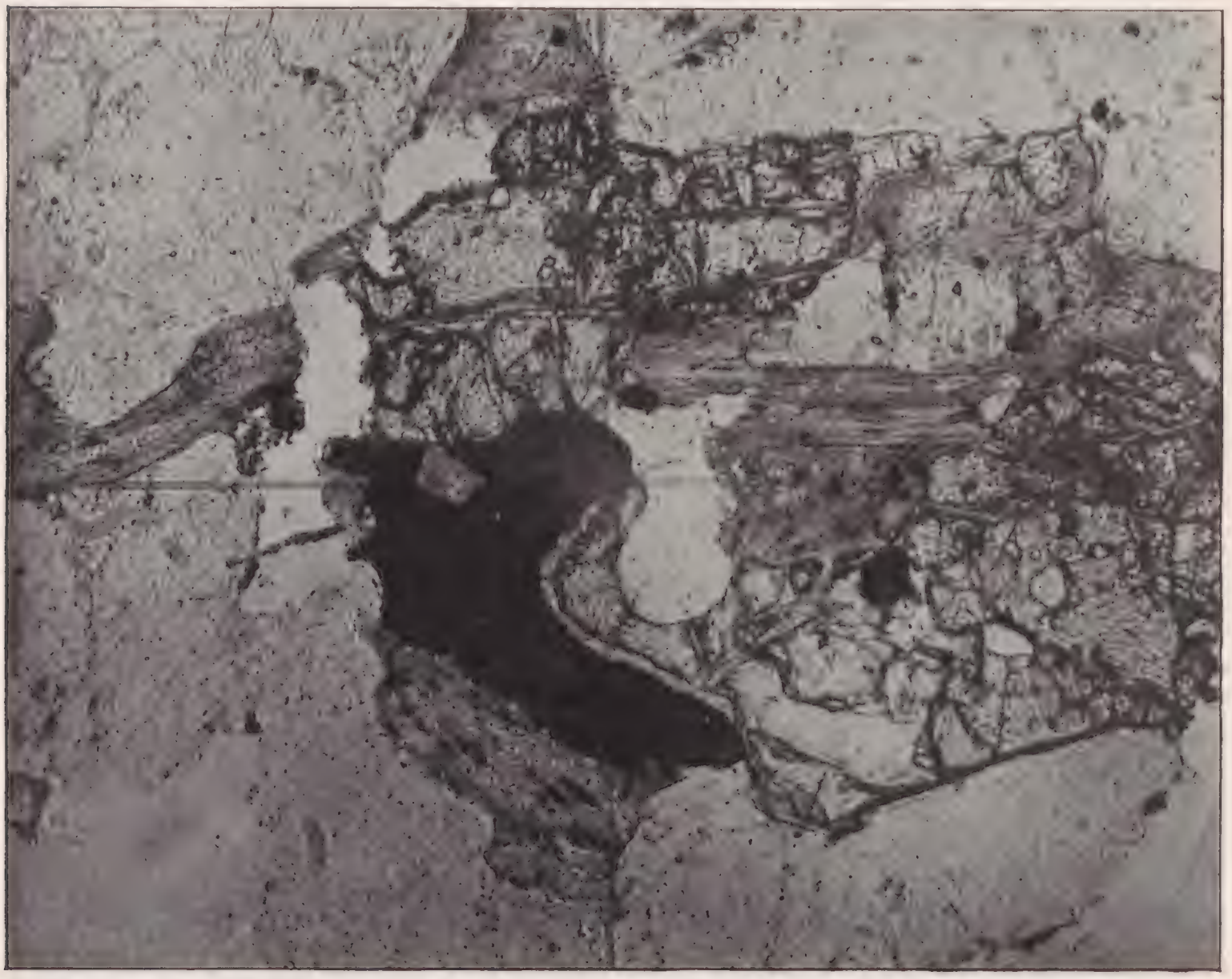

Fig. 4 Photomicrograph of rusty gneiss underlying the ore at the Cole mine, showing pyrite molded upon garnet. (Magnified 83.5 diameters)

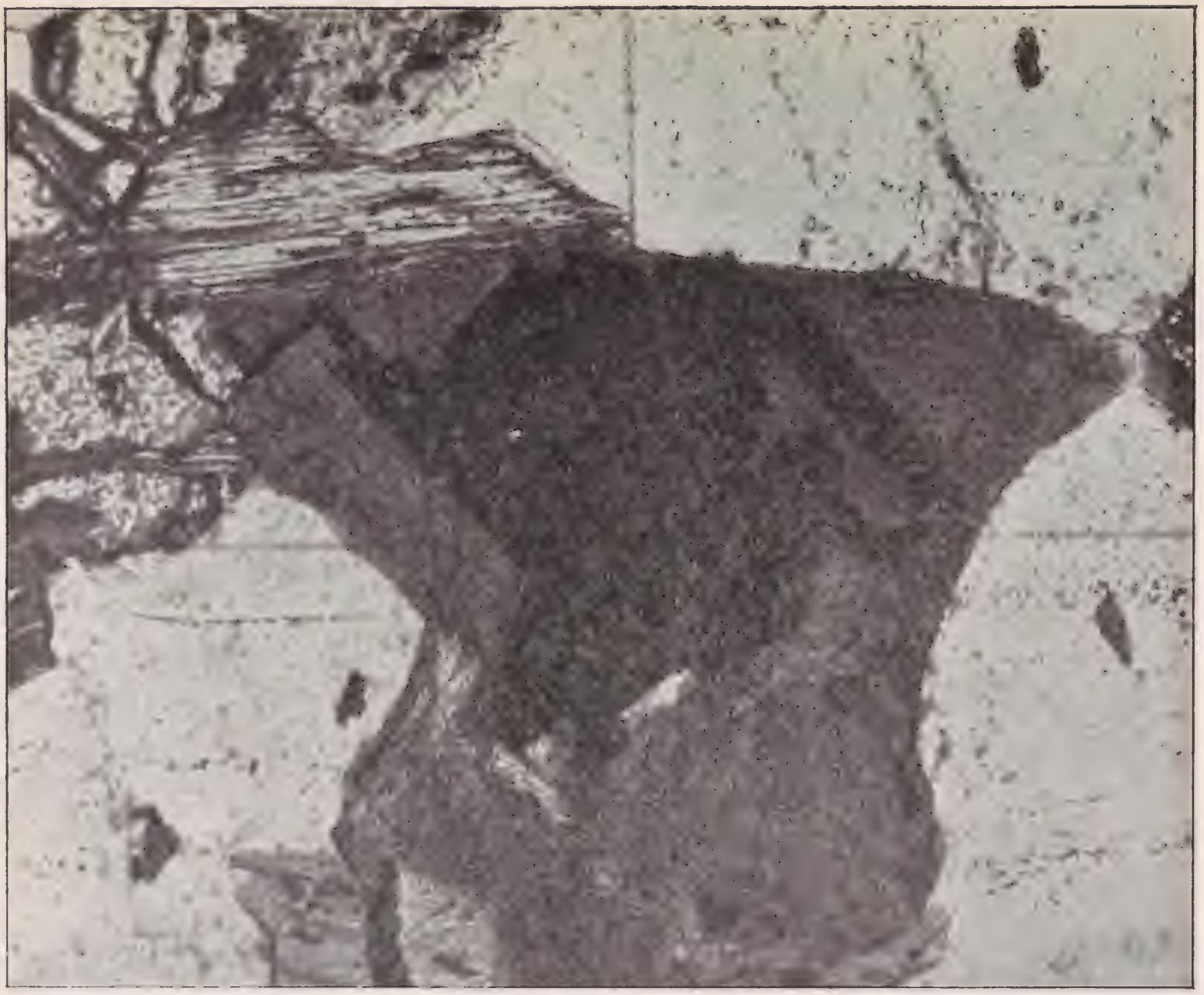

Fig. 5 Photomicrograph of rusty gneiss underlying the ore at the Cole mine, with pyrite growing in chlorite, surrounded by quartz, garnet and bleached mica. (Magnified 154 diameters)

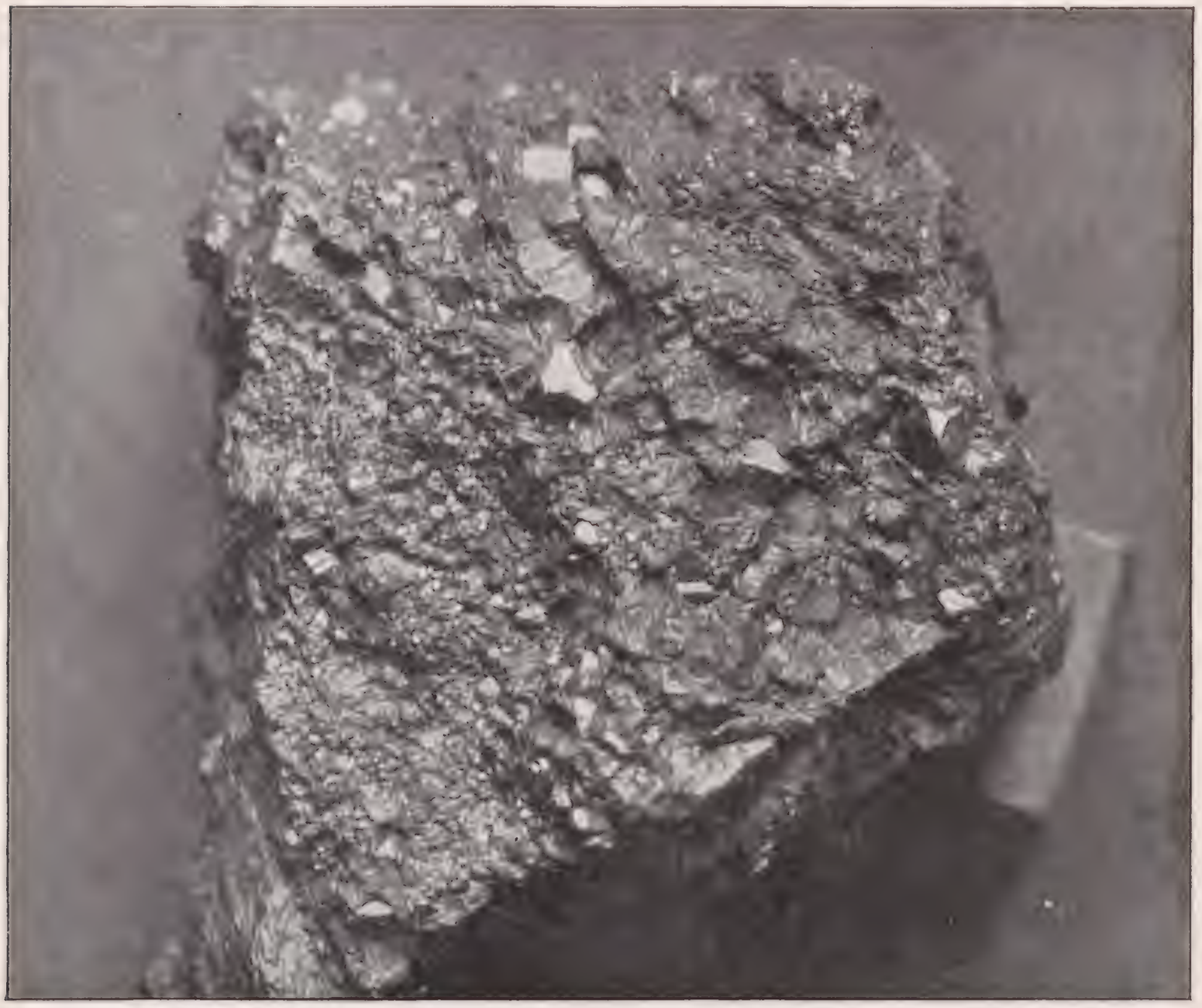

Fig. 7 Ore at the Hendricks mine, with crystals of pyrite in a chloritic aggregate. (9/10 natural size)

The gneiss in the hill is typical Grenville and is confidently classed as sedimentary, and thus the ore body lies wholly within sedimentary rocks. Pegmatite, however, is abundant, appearing as irregular masses but more commonly injected in thin sheets parallel to the banding of the gneisses. It is particularly abundant in immediate association with the ore but apparently contains no pyrite. This is so unlike other localities, however, that it is probable pyrite was overlooked. The ore appears to be merely a modification of the ordinary gneiss, containing large, but variable, amounts of pyrite. There is a gradual transition from gneiss to ore, no sharply defined ore body being present.

More than at any other mine, the pyrite tends to occur in distinct crystals which seem to form quite regardless of surrounding minerals. This is particularly true of a variety of ore consisting of a very fine chloritic aggregate, evidently an alteration product, through which are scattered abundantly quite perfect crystals of pyrite, seldom more than half an inch in diameter, and showing nothing more complex than cube and pyritohedron, as far as noticed (figure 7). This is evidently an extreme case of the tendency shown at all mines for the pyrite to crystallize more perfectly when in a chloritic matrix. As at the Cole mine, graphite is a constant accompaniment of the pyrite, though quite unevenly distributed. A considerable amount of milky white quartz is present, of vein origin and younger than the pyrite crystals, while there has been a still later deposition of calcite in limited amount.

Thin sections confirm the conclusion drawn from field study that the ore is a part of the Grenville gneiss enriched in pyrite at the expense of the other minerals. The ordinary gneiss on the ridge is a rather fine grained aggregate of quartz, feldspar, both orthoclase and plagioclase, abundant muscovite and a pale brown mica, probably phlogopite. There is a little graphite and an occasional grain of pyrite. A similar rock, close to the ore, is darker in color, very quartzose and micaceous, with more graphite and considerable pyrite. The mica is changing into a greenish, chloritic material of weak or indistinguishable double refraction, and sometimes with a fibrous texture. This same substance also grows in quartz and feldspar, together with small quantities of sericite. There is also present some colorless pyroxene and a dark brown mineral, probably rutile.

In the sections, as in hand specimens, the pyrite seems to have grown freely into other minerals and only occasionally is molded upon them. Although in somewhat elongated and branching aggre-

gates, it nearly always has its margins bounded by crystal faces (figure 8). There are some delicate aggregates of small crystals clustered in such a way as to indicate that they have crystallized within the rock after all mechanical disturbances. This rock is a perfectly typical rusty gneiss of the Grenville, and at the same time, when compared with the preceding rock, it is clearly the first stage in the conversion of a similar rock into ore.

Next, a lean ore shows in the section all the mica changed to chloritic material. There is a little rutile, but no graphite. The pyrite is in large areas, bounded by crystal outlines not of single crystals, but of many crystals in a single mass as shown in figure 9. Feldspar is practically absent, and the abundant quartz is largely, if not wholly, a secondary infiltration.

Another section of lean ore shows large single, but somewhat incomplete crystals of pyrite with considerable feldspar altering to sericite, and much green chlorite. The larger crystals of pyrite partly or wholly inclose grains of the other minerals, clearly indicating an incomplete replacement of the latter by the pyrite (figure 10). Another section differs from this only in the abundance of graphite, resembling in this respect many specimens from other localities, while the Hendricks material, on the whole, is rather poor in this constituent. Another hand specimen shows much vein quartz and rather perfect crystals of pyrite. In thin sections the latter is seen to be crushed and the cracks infiltrated with calcite.

As bearing upon the question of genesis of the pyrite deposits, the most striking phenomena exhibited at this locality are the close association of the ore body with crystalline limestone, the gradation of ore into rusty gneiss and ordinary fine laminated gneiss, the irregular distribution of graphite in the ore and often its entire absence, the crystalline character of the pyrite apparently assumed late in the history of the rock and but little controlled by other minerals present, the alteration of mica to a chloritic material, which seems to grow also at the expense of other minerals, and finally the presence of considerable vein quartz. The small amount of calcite appears to be of minor importance, but on the other hand it is possible that the injection of pegmatite in the gneiss of the adjacent ridge is a vital factor and its presence must be kept in mind in framing hypotheses to account for the ore bodies. The crushing of pyrite shown in one section simply serves to accentuate the extreme rarity of this phemonenon throughout the region, for while there has doubtless been considerable disturbance subsequent to the formation

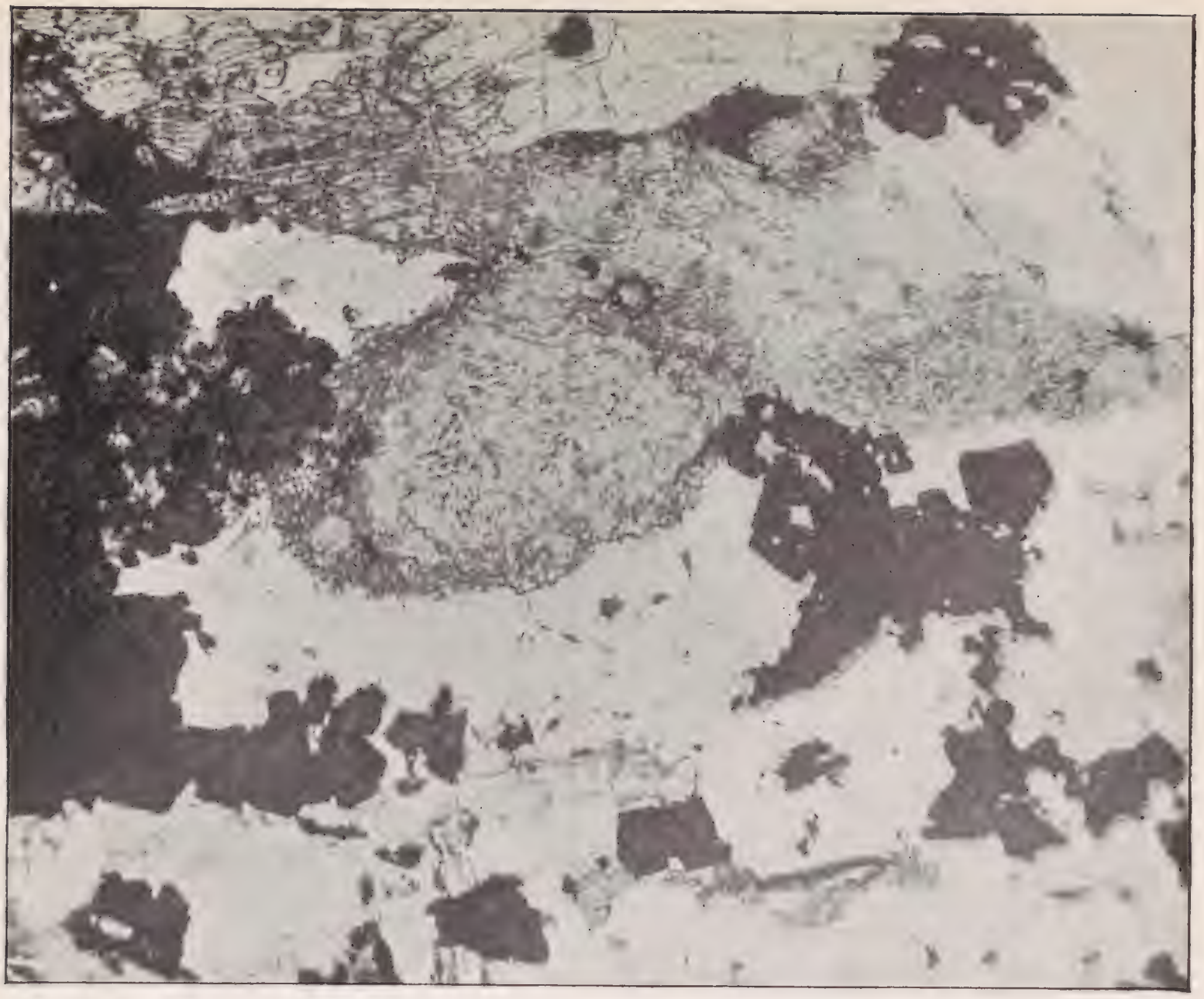

Fig. 8 Photomicrograph of rusty gneiss close to ore, Hendricks mine, with irregular masses of pyrite scattered through quartz, pyroxene, chlorite and sericite. A little mica and a few flakes of graphite are present. (Magnified 27.5 diameters)

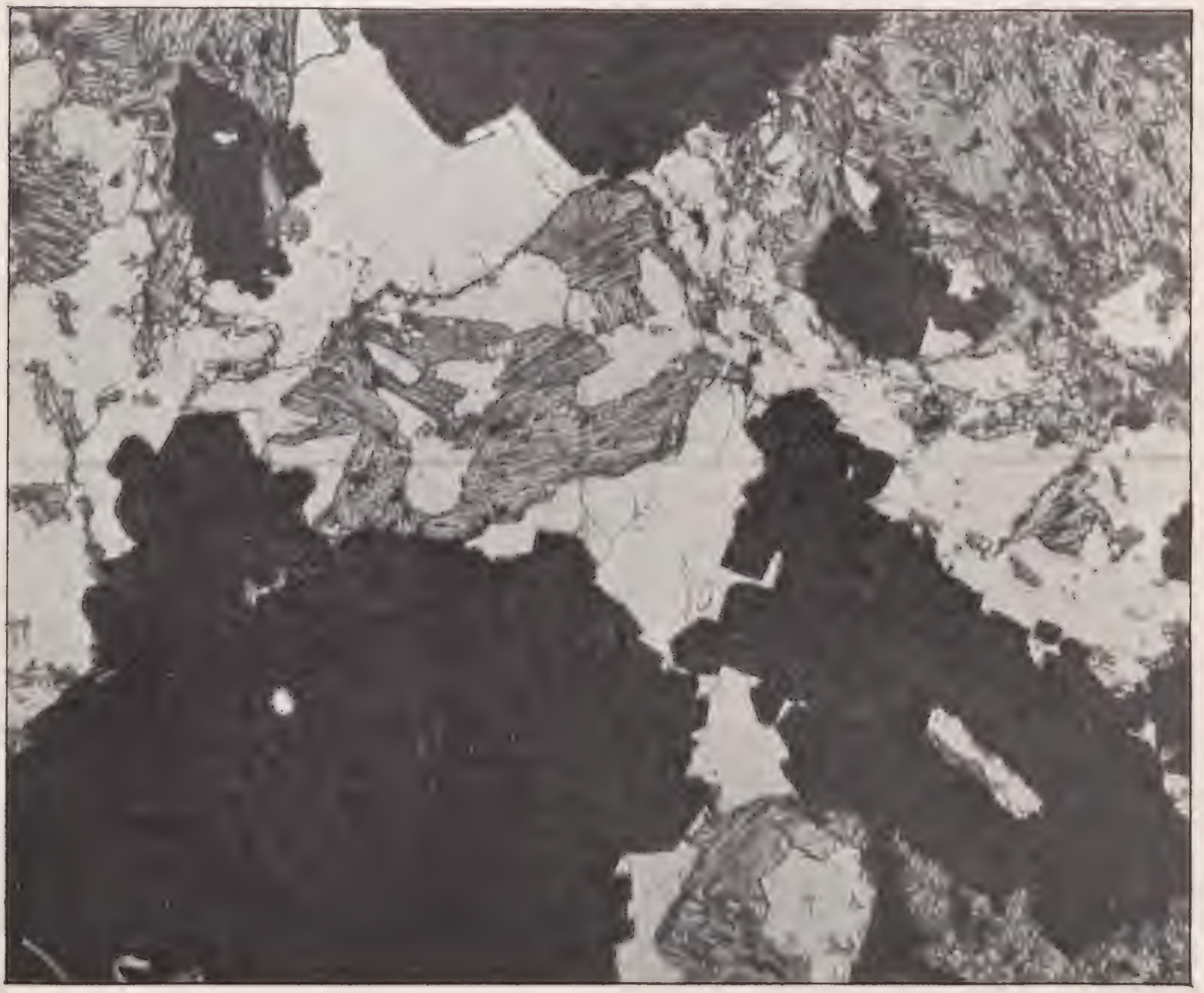

Fig. 9 Photomicrograph of lean ore, Hendricks mine. Large masses of pyrite, bounded by sharp crystal faces, with quartz, chloritized mica and a little rutile. (Magnified 27.5 diameters)

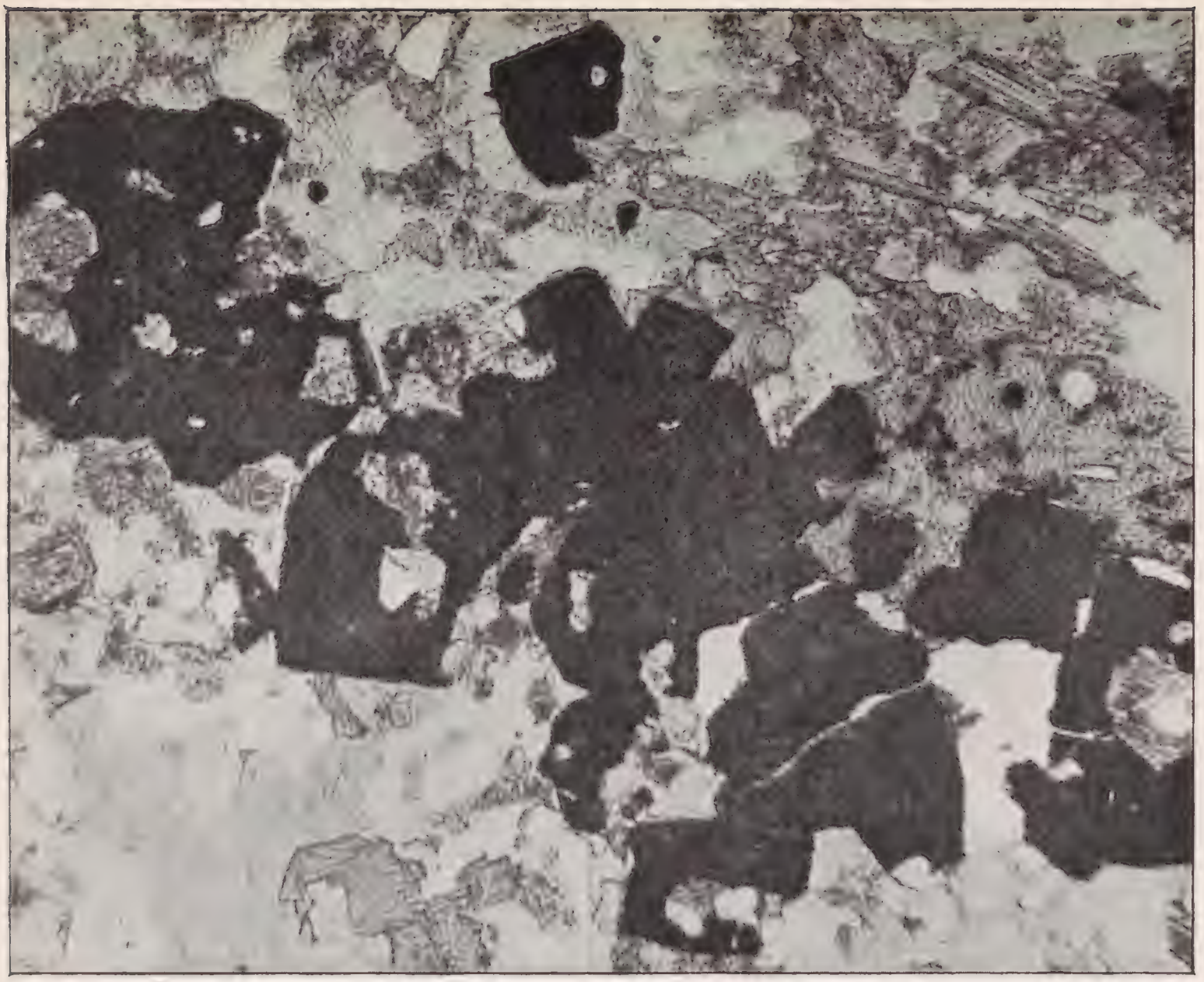

Fig. 10 Photomicrograph of lean ore, Hendricks mine, with incomplete crystals of pyrite developed in chlorite, bleached mica, kaolinized feldspar (in part plagioclase) and quartz. A few cracks shown in the pyrite were made in grinding the section. (Magnified 27.5 diameters)

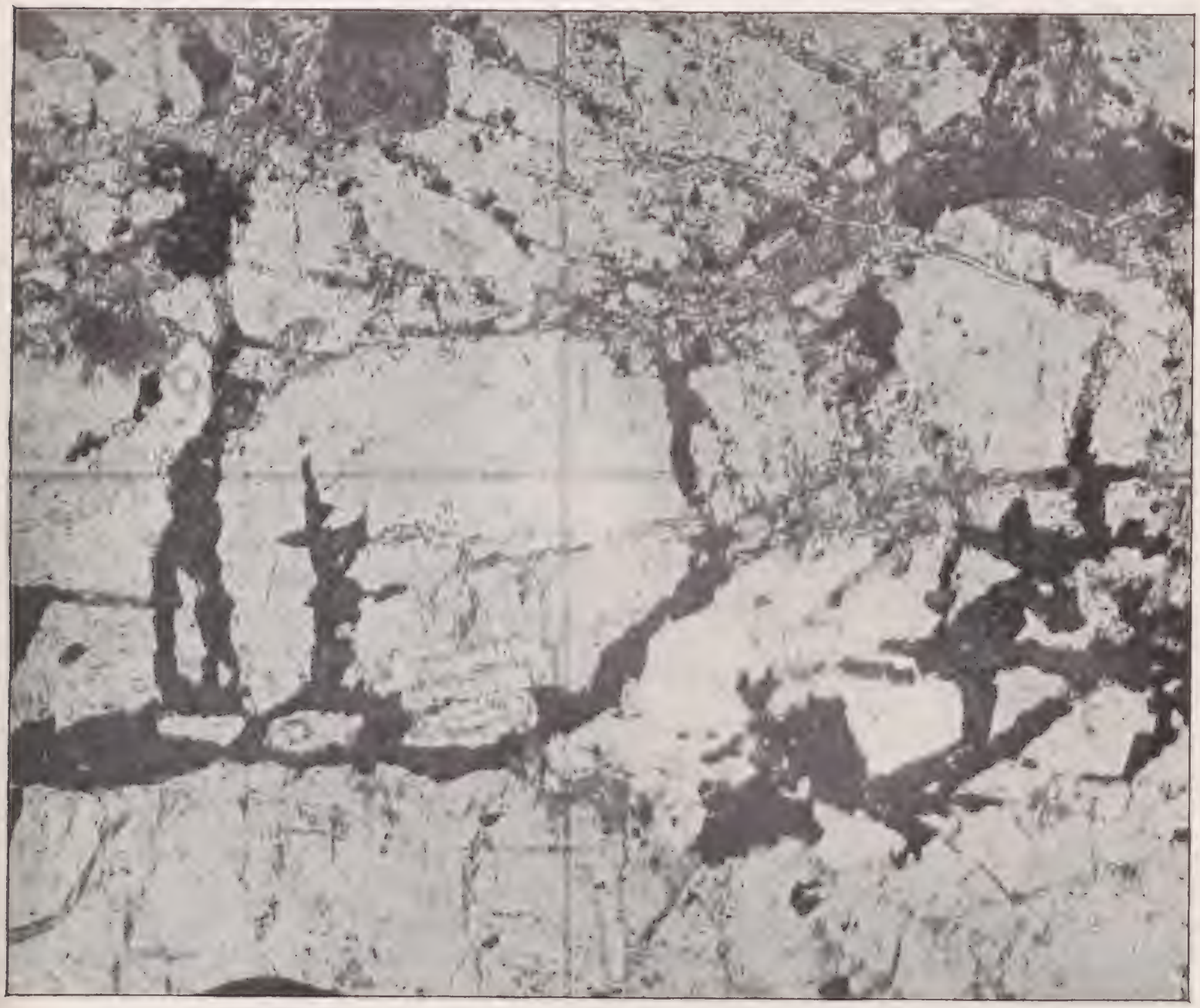

Fig. 12 Photomicrograph of pyritiferous pegmatite, Styles mine, with pyrite, chlorite and sericite developed along cracks in feldspar. (Magnified 83.5 diameters)

of pyrite, it has not been of such a nature as to effect a comminution of the rock constituents.

THE STYLES MINE

On the Styles farm, a few miles farther northeast, another small prospect has been opened. Here again the pyrite is in the rusty gneiss and its Grenville association is strikingly shown by the fact that this gneiss is hardly more than twenty feet thick and has limestone both above and below, as shown in figure 11.

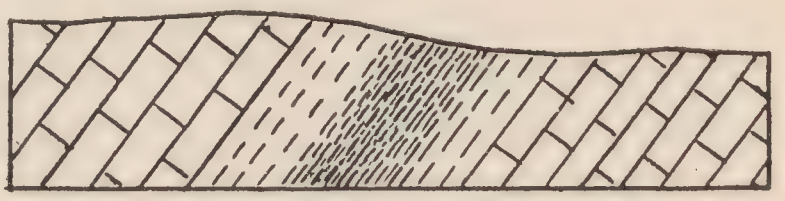

Fig. 11 Rusty gneiss and ore heavily shaded

In addition to these rocks considerable pegmatite, carrying a peculiar light brown tourmalin, is present, a great deal lying on the dump. While much of the pegmatite is free from pyrite, other specimens show considerable quantities of the mineral. Indeed some of the pegmatite is a rather lean ore of pyrite, while the rich ore seems again to be merely a part of the rusty gneiss carrying an unusually large percentage of pyrite. As at the Cole mine, graphite is conspicuous in the richer ore which also contains large amounts of grayish green, soft chloritic material not conspicuous at the Cole mine, but very abundant and characteristic at other localities. Indeed, in many cases, it appears that the enrichment of ore is roughly proportional to the development of this chloritic product.

Thin sections of the Styles pegmatite show moderately developed cataclastic structure, which is of particular interest since it evidently precedes the deposition of pyrite. The latter, with some chlorite and sericite, spreads in a network through the cracks between the mineral fragments recementing the fractured rock. But the process, instead of stopping at this point, evidently continued as an actual replacement of the mineral grains by pyrite, thus increasing the latter at the expense of the former (see figures 12 and 13). This may continue to the production of a rich ore. Indeed, among the specimens collected the richest is quite probably a highly altered pegmatite converted into an ore by this process of replacement. As at the other localities, graphite is quite generally present.

A section of another specimen of pegmatite shows the same kataclastic structure, with pyrite filling cracks and from them spreading into and replacing the original minerals. There is also a more perfect development of crystal form of pyrite when in contact with chlorite rather than with primary minerals. This relation as already indicated is shown by sections from several localities and strongly

suggests that the soft chlorite is easily displaced mechanically, as well as chemically, by the pyrite, a conclusion which of course implies the later formation of the last named mineral. That this is true of at least part of the pyrite, there can be no doubt. The section in question is a cataclastic pegmatite, similar to that from which figure 13 is taken, and shows the same development of pyrite, beginning in cracks and extending from them into the surrounding solid minerals.

THE FARR MINE

The Farr mine, some two miles northeast of the Styles mine, resembles the latter very closely in its geological relations. Here again the ore is part of a narrow band of rusty gneiss hardly exceeding thirty feet in thickness, with limestone above and below, while again pegmatite is conspicuous. There is a large mass of the latter rock, free from pyrite, some twenty feet from the shaft, while in the dump there is abundant pegmatite containing much pyrite. As the latter increases in quantity it passes into fairly rich ore. Judging from what could be seen when the locality was visited, the pyritiferous pegmatite is an important part of the ore. The rock contains an abundance of the light brown tourmalin seen in the pegmatite of the Styles mine. This mineral is conspicuous in some of the strongly replaced specimens.

A section of the pyritiferous pegmatite shows large areas of pyrite from which veinlets extend out into the surrounding quartz and feldspar. Figure 14 shows an example where such veinlets traverse what was originally a single individual of quartz, without the slightest disturbance in optical orientation of the now separated parts. It is clear that these parts have not been moved with reference to each other, but that the pyrite has replaced an equivalent amount of quartz, the process starting along minute cracks. Its continuation would lead to a complete replacement of quartz by pyrite, which is doubtless the manner in which the larger masses of pyrite have originated. An even better case, perhaps, is shown in figure 15 where the veinlets of pyrite traverse several individuals of quartz, with no disturbance of their optical orientation and continue down through several other grains, outside of the field of the microscope. The only section of schist from this locality examined under the microscope shows, in addition to the ordinary quartz, feldspar and mica, sillimanite, tourmalin, garnet, some pyrite and graphite. It is evidently a Grenville sediment, but presumably has been affected by the pegmatite, as indicated by the tourmalin.

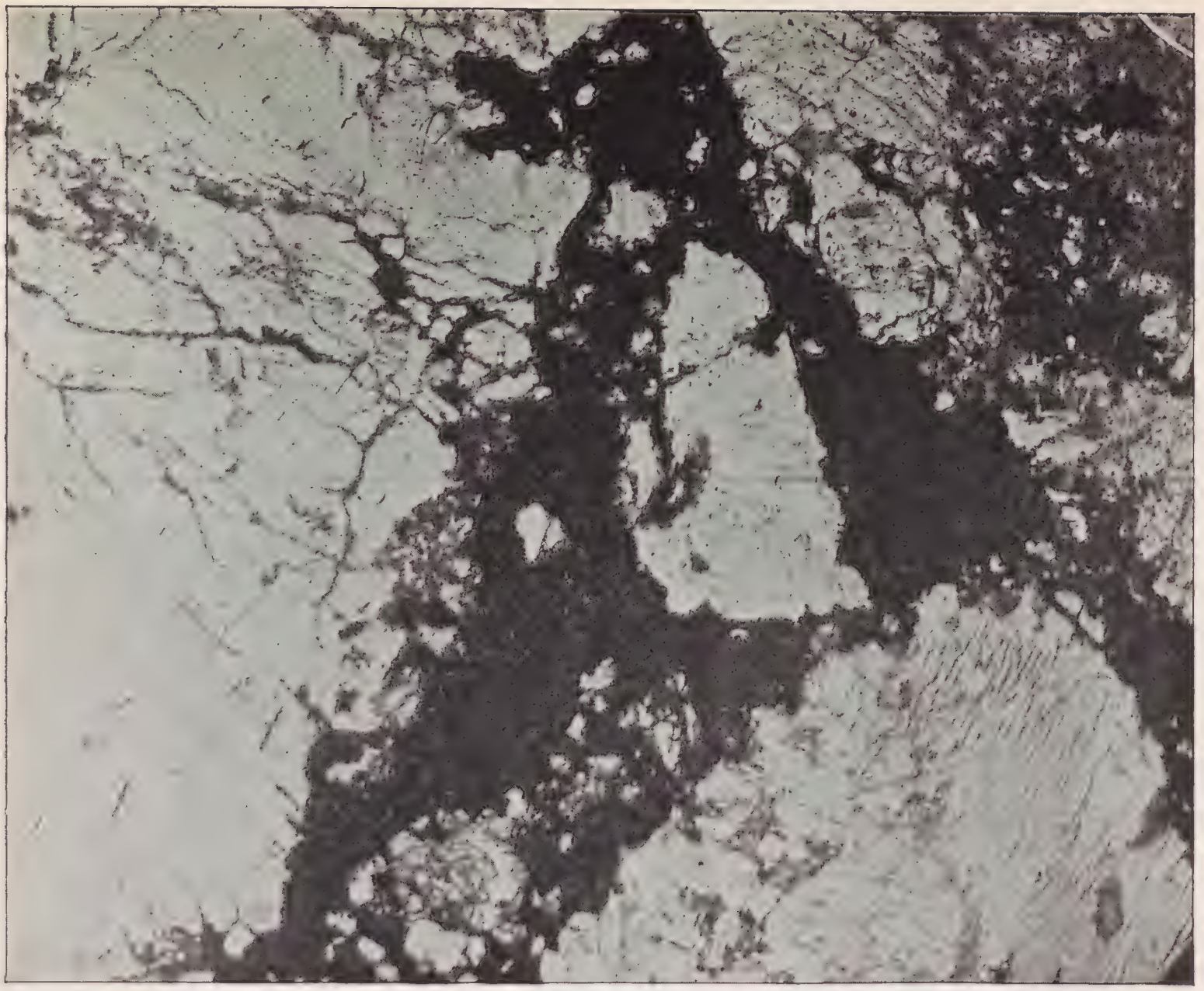

Fig. 13 Photomicrograph of pyritiferous pegmatite, Styles mine. Quartz and feldspar showing cataclastic structure and subsequent development of pyrite. (Magnified 27.5 diameters)

Fig. 14 Photomicrograph of pyritiferous pegmatite, Farr mine, showing veinlets of pyrite cutting a single individual of quartz without disturbing the optical orientation. (Magnified 60.5 diameters)

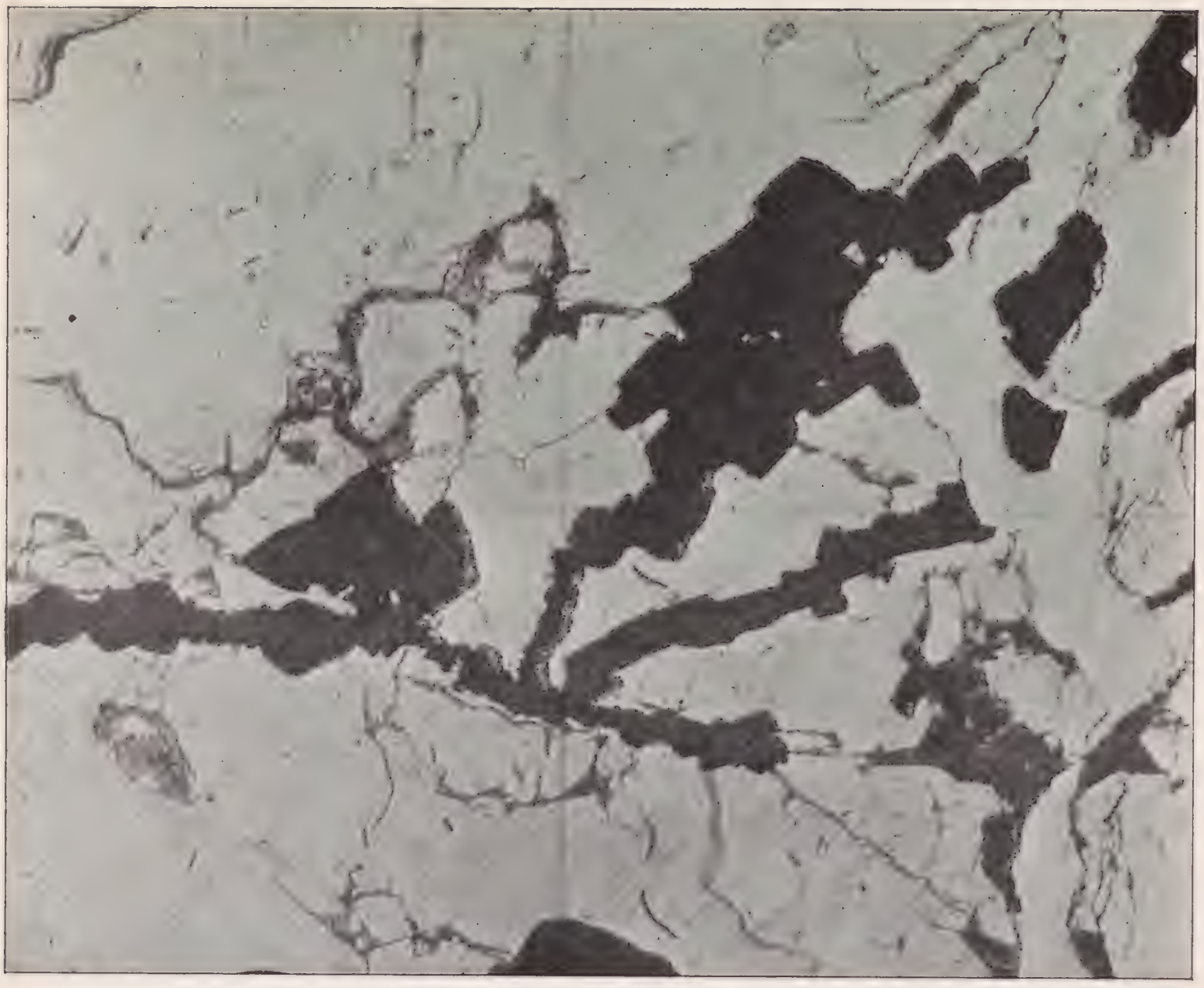

Fig. 15 Photomicrograph of pyritiferous pegmatite, Farr mine, with branching veinlets of pyrite cutting several individuals of quartz without disturbance of optical orientation. Crystal boundaries of pyrite, very sharp. (Magnified 27.5 diameters)

Fig. 17 Ore, Stella mine. A rather fine, granular aggregate of pyrite, chlorite, graphite, quartz and feldspar. (9/10 natural size)

While in all these cases the pyrite is manifestly introduced into its present position very late in the history of the rock, the question arises: Has it been brought into the rocks from an outside source subsequently to their formation or is it an original constituent which has merely undergone secondary migration and recrystallization? The answer to this question may be different for the pyrite in gneisses, on the one hand, and for that in pegmatites, on the other, but as in either case the whole problem of the origin of the ore bodies is involved, the consideration of the matter is deferred for the present.

THE STELLA MINES

About five miles northeast of the Farr mine are located the Stella mines, much the most extensive workings of the pyrite region. In many respects the geology is similar to that of the localities already mentioned, but at the same time there are some striking differences. The mines lie in a Grenville belt, with extensive development of rusty gneisses southward and heavy limestone on the north. At the mines the exposed section begins on the south with a coarse, rather massive, very dark hornblende gneiss, quite unlike any rock shown at the other localities. This rock forms a ridge south of the new Anna shaft, on the lower ore body, which is the next member of the series and which in its natural exposures is a typical rusty gneiss. Above this comes another gneiss forming a high ridge between the two ore bodies. At the bottom, this rock is light gray and appears fairly acid, but higher up it becomes dark and hornblendic, resembling closely the lower hornblende gneiss, and then finally becomes acid again toward the top. Next comes the rusty gneiss of the upper ore body, and this is followed in turn by a light gray mica gneiss, making up a considerable ridge, with limestone to the north. This generalized section is represented in figure 16.

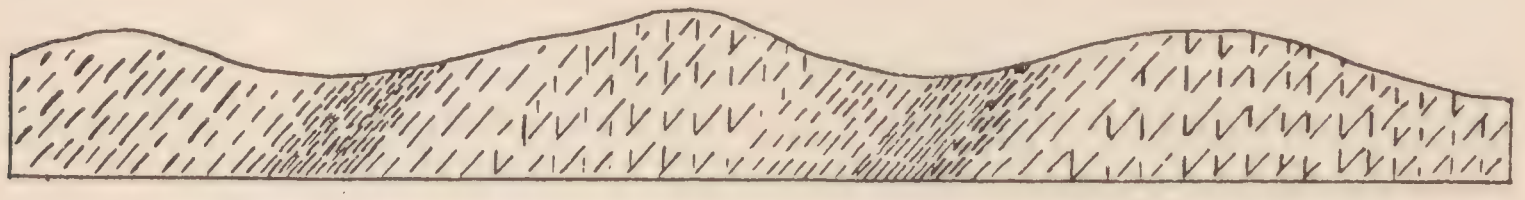

Fig. 16 Hornblende gneiss shown by crossed hachures

As compared with sections at the other localities, the entire absence of limestones is perhaps the most striking feature. The two distinct main ore horizons are also worthy of note, while perhaps more important is the great development of gneiss. The high ridge of gneiss above the ore at the Hendricks mine is in some ways

analogous to the mica gneiss above the upper ore at Stella, but the rocks at the two localities are quite unlike, while at none of the previously described localities is there anything resembling the dark, hornblende gneiss in the present section. The ore deposits themselves and the immediately associated rock appear without doubt to be of the same general type as elsewhere.

While in the preceding cases it has been clear that all rocks concerned, with the exception of the pegmatites, were of the generally accepted Grenville sedimentary types, at Stella this is far from being the case, and for the first time the question of the origin of extensive rock bodies presents itself.

The problem begins with the dark, hornblendic gneiss at the bottom of the section. This is a type of rock that might result from the metamorphism of a sediment or of a basic igneous rock. In the present case conclusive evidence is not afforded for deciding between the alternatives, but from a general knowledge of the region, and more particularly from evidence to be given in connection with another locality, the writer inclines to regard the rock as igneous and closely related to the gabbros of the region. Yet this view meets difficulties when the gneiss between the ore bodies is examined. The central part of this can hardly be distinguished from the supposed gabbro, but it shades both upward and downward into a light gray, rather acid gneiss that might well be interpreted as a Grenville sediment. Evidently this difficulty might be explained in diverse ways, but without very detailed study speculation would be fruitless. Finally, the mica gneiss above the upper ore is regarded as probably sedimentary, but on the other hand it too may be a metamorphosed intrusive so far as can be judged by its structure and mineralogical composition.

While these unsettled questions obviously are important in their bearing upon the history of the ore deposits, they are not so vital as they would be were this the only locality for the pyrite or did the deposits here differ markedly from those at the other localities. As a matter of fact, this latter is conspicuously not the case, the ore bodies at Stella agreeing in all important details with those already described. This being true, it follows that the nature of the ore deposits is independent of the immediate presence of large intrusive masses, since none occur at the other localities, and the probable and possible intrusions at Stella have exerted no noticeable modifying influence upon the ore bodies. The latter are of rough lens shape,

dipping to the north with the country rock. At present ore bodies lying at two distinct horizons, separated by about a thousand feet across the strike, are worked, and the superintendent of the mines, Mr J. Tonkin, informed the writer that a total of nineteen ore bodies of varying thickness had been shown by diamond drilling. According to Mr F. T. Rubidge, vice president of the St Lawrence Pyrites Co., to whom the writer is indebted for many courtesies, only four or five of the pyritiferous horizons afford workable ore-bodies. They run about twelve feet in thickness, but may reach as high as thirty feet. In the Stella mine, the ore, about ten feet thick, extends about eleven hundred feet along the strike and has been worked nine hundred feet down the dip of 20°–30°. Considerable pyrrhotite occurs in this mine. In the Anna mine, the ore averages twenty feet thick and has been followed two hundred fifty feet down a 45° dip and twelve hundred feet along the strike. As elsewhere, the ore bodies are not sharply defined but fade gradually into the surrounding rock, which is impregnated with pyrite some distance from the ore proper. While the typical ore lies in the rusty gneiss, pyrite is disseminated rather generally through the rocks, and railroad cuts in the hornblendic gneiss south of the mines show strongly pyritiferous masses of irregular form, the pyrite being in a tough dark base. The same rock is also cut by many bands of pegmatite, both parallel to and across the foliation. These bands frequently carry pyrite in crystals and it also occurs in irregular branching veins in the gneiss.

The gneisses above and below the upper ore body carry a great deal of sheared pegmatite, mostly parallel to the foliation, and this carries some pyrite. Thus here, as elsewhere, the pegmatite is conspicuous. The same is true of graphite, for just as at the Cole mine, the tailings from the concentrator carry considerable amounts of this mineral, which also is more abundant in the ore and immediately adjacent rocks than farther from the ore bodies.

Hand specimens of the ore show a granular aggregate of pyrite, graphite and a gray, soft alteration product, together with some quartz and feldspar (see figure 17). Some specimens can hardly be distinguished from the material at the Cole mine but large crystals are less frequent at Stella.

Here and there vugs occur, lined with crystals of quartz, calcite and sphalerite, manifestly much younger than the pyrite and formed under quite different conditions.

A thin section of a rather lean ore from the Stella shaft, showing to the naked eye pyrite, graphite, quartz, feldspar and the usual soft gray material, under the microscope shows much nearly isotropic chloritic alteration product mingled with bleached mica and sericite. There is also considerable quartz and some untwinned feldspar. Graphite is abundant, much of it being inclosed in the pyrite though in one or two instances the latter mineral has grown between and forced apart plates of graphite. The pyrite is often in distinct crystals which apparently have been the last development in the rock unless it be the alteration products. As to the latter there is some uncertainty, for while the chlorite sometimes forms borders around or veins in pyrite there is a tendency, noted elsewhere, for the pyrite to have more perfect crystal form when in contact with chlorite, as though the latter were more yielding than the other minerals. Without doubt some of the chlorite, and probably most of it, antedates the pyrite, while the very pronounced formation of chlorite in the pyritiferous rocks, as compared with the average gneisses, strongly indicates a direct connection between chloritization and deposition of pyrite, as products of closely related and associated processes and conditions. So far as the evidence goes this rock seems to be a highly altered gneiss carrying unusual quantities of graphite and pyrite, the latter mineral having evidently formed very late, replacing the older minerals.

A section of richer ore differs greatly from the preceding, having even more graphite, and the pyrite developed almost to the complete exclusion of other minerals. The section is quite striking, showing the pyrite in distinct though interlocking crystals including abundant graphite, the interspaces being filled with sericite, secondary quartz and chlorite (see figures 18 and 19). Though as a whole so unlike the preceding section, this one shows remnants of greatly altered minerals of the gneiss and there can be no doubt that this rich ore is a part of the gneiss in which the processes of alteration and replacement have been carried to an extreme degree.

The immediate hanging wall of the Stella ore body is a fine-grained dark gray schist, with much graphite, shot through with tiny veins and bunches of pyrite (see figure 20). A thin section shows it to be a graphite-mica schist, the graphite giving the dark color. The mica is largely altered to a weak doubly refracting chlorite similar to that in the ores, and sometimes to a fibrous mass of yellowish brown color. Areas of this latter sometimes have a narrow border of sericite. Quartz is abundant, but feldspar is present only in very small quantity, and none with the twinning of plagioclase.

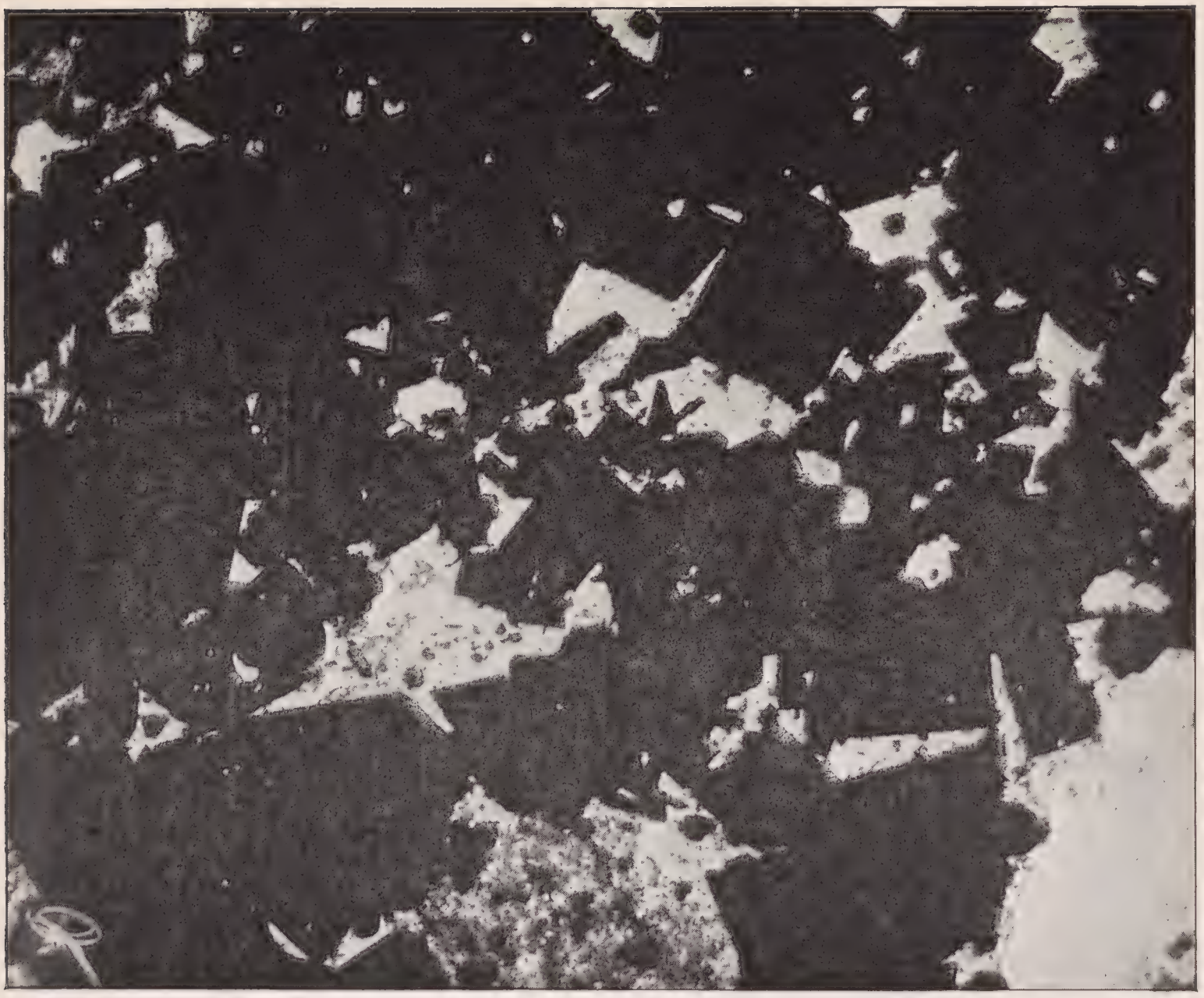

Fig. 18 Photomicrograph of rich ore, Stella mine. The spaces between the sharp crystals of pyrite are filled with sericite, chlorite and secondary quartz. Graphite is abundant in the pyrite, where, of course, it does not show in the photograph, and as small flakes and elongated grains in the light colored minerals. (Magnified 27.5 diameters)

Fig. 19 Photomicrograph of rich ore, Stella mine. Rather large crystals of pyrite, with graphite, sericite, chlorite and secondary quartz. (Magnified 27.5 diameters)

Fig. 20 Hanging wall, Stella mine. A fine-grained, dark, graphitic schist with veins of pyrite roughly parallel with the foliation. (9/10 natural size)

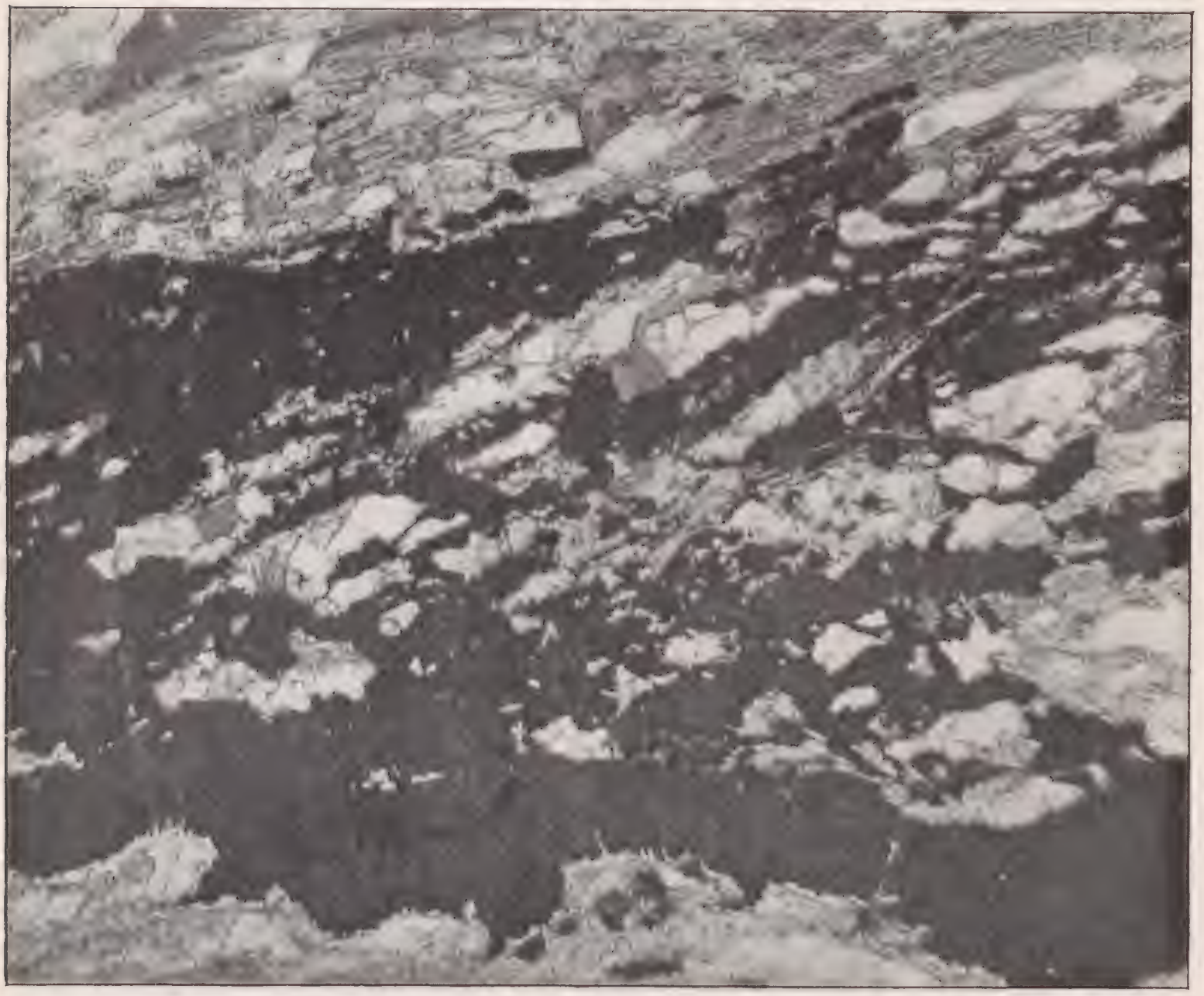

Fig. 21 Photomicrograph of hanging wall, Stella mine, showing a section of one of the pyrite veins of figure 20. Crushed quartz, chlorite, sericite, graphite and bleached mica, with pyrite in anastomosing veinlets, commonly bordered with a narrow fringe of sericite. (Magnified 27.5 diameters)

Graphite is abundant in scales and plates arranged parallel to the distinct foliation. Very commonly the graphite is somewhat split or even shredded, with chlorite, sericite and pyrite filling its interspaces into which they have evidently penetrated after the crystallization of the graphite. Like the graphite, pyrite is usually elongated parallel to the foliation, occurring most often in irregular grains. The section shows one of the veinlets seen in the hand specimen. It is made up of many fine anastamosing branches parallel to the foliation, the pyrite often showing distinct crystal form, while the outer margins of the vein are bordered with the sericite, whose position and arrangement are so evidently controlled by the vein that there can be no doubt that the sericite formed after the pyrite (see figure 21). That the latter mineral is a replacement of the ordinary constituents of the rock seems equally certain, being localized by solutions circulating in relatively porous parts of the rock. Had the replacement proceeded further an ore similar to those actually worked would have resulted.

The foot wall of the Stella ore body is a much coarser rock than the preceding, lighter colored and less prominently foliated. Large cleavage faces of feldspar are shown and many scattered grains of pyrite, but the pyrite veinlets so conspicuous in the hanging wall are lacking. In thin section, orthoclase is very abundant, passing over into the usual greenish, nearly isotropic, chloritic alteration product. Mica is thoroughly bleached, or completely altered to chlorite. There are some large areas of clear interlocking quartz possibly of vein origin. As a whole the section suggests a much altered, sheared pegmatite or injection gneiss. No graphite is shown and pyrite is not abundant, occurring as rather evenly disseminated, irregular grains which have a tendency to lie in chlorite, though there are abundant exceptions to this rule. The pyrite often shows a variety of skeletal growth, having the interspaces filled with chlorite and sericite, as shown in figure 22. Here there is a green, low refracting, chloritic alteration of feldspar clearly shown in process of formation, in the large feldspar grain on the right, and the same material filling cavities in the pyrite, near the bottom. Apparently this is older than the pyrite. Quite distinct from this is the filling of the spaces between the slender tongues of pyrite, by nearly colorless, strongly doubly refracting sericite, clearly younger than the pyrite. Pyrite is also seen replacing orthoclase and bleached mica. It is, perhaps, worthy of note that the disseminated pyrite is quite as abundant in this rock lacking graphite as in the hanging rock containing the latter in abundance.

Another specimen from the foot wall is a pyritiferous pegmatite quite similar to that at the Farr mine. It is a coarse aggregate of quartz, feldspar, green from alteration, and pyrite. In thin section it bears a strong resemblance to the preceding rock, but is coarser. The feldspar appears in all stages of alteration to the chloritic aggregate, and the pyrite occurs in this rather than in the quartz. At several points there is a pronounced skeletal growth (see figure 23) of pyrite in the chlorite, and here the latter mineral is somewhat fibrous, the fibers being perpendicular to the pyrite margins and meeting along a straight line in the middle of the narrow veinlike spaces. The conclusion seems unavoidable that this part of the chlorite has been deposited after the pyrite, or has undergone some rearrangement with reference to it. The latter is more probable. At another point, chlorite fills a narrow tortuous space between pyrite and quartz and between two adjacent grains of pyrite. Again, the fibrous chlorite has its fibers in clusters radiating from points along the margins of sharply banded pyrite crystals. Elsewhere the chlorite is clearly molded upon quartz. All these relations point to the mobility of the first-named mineral.

In general the microscopic examination of these sections strengthens the impression gained from other thin sections and in the field, that there is a close connection between the formation of pyrite and of chlorite. Many exceptions occur where pyrite is associated with fresh quartz and silicates but the ores proper all show the chloritic alteration. Practically the same thing may be said of pyrite and graphite, the latter being usually abundant but sometimes absent.

Sections of the gneisses adjacent to the mines shed little light upon their origin. They are aggregates of hornblende, plagioclase, a little pyroxene and some quartz and while, as previously stated, they are thought to be igneous rocks related to the gabbros, their true nature is open to question and they may be metamorphosed sediments. This latter view is favored by Newland.[1]

The material of one of the small pyritiferous bands in the dark hornblende gneiss, south of the Anna shaft, is of interest when compared with the large ore bodies. The hand specimen shows a rather coarse aggregate of hornblende, an amorphous black material and pyrite, the latter often in good crystals. The thin section shows some hornblende, greatly decomposed feldspar, apatite and an

[1] Newland, D. H. The Mining and Quarry Industry of New York. N.Y. State Mus. Bul. 120, 1908, p. 51.

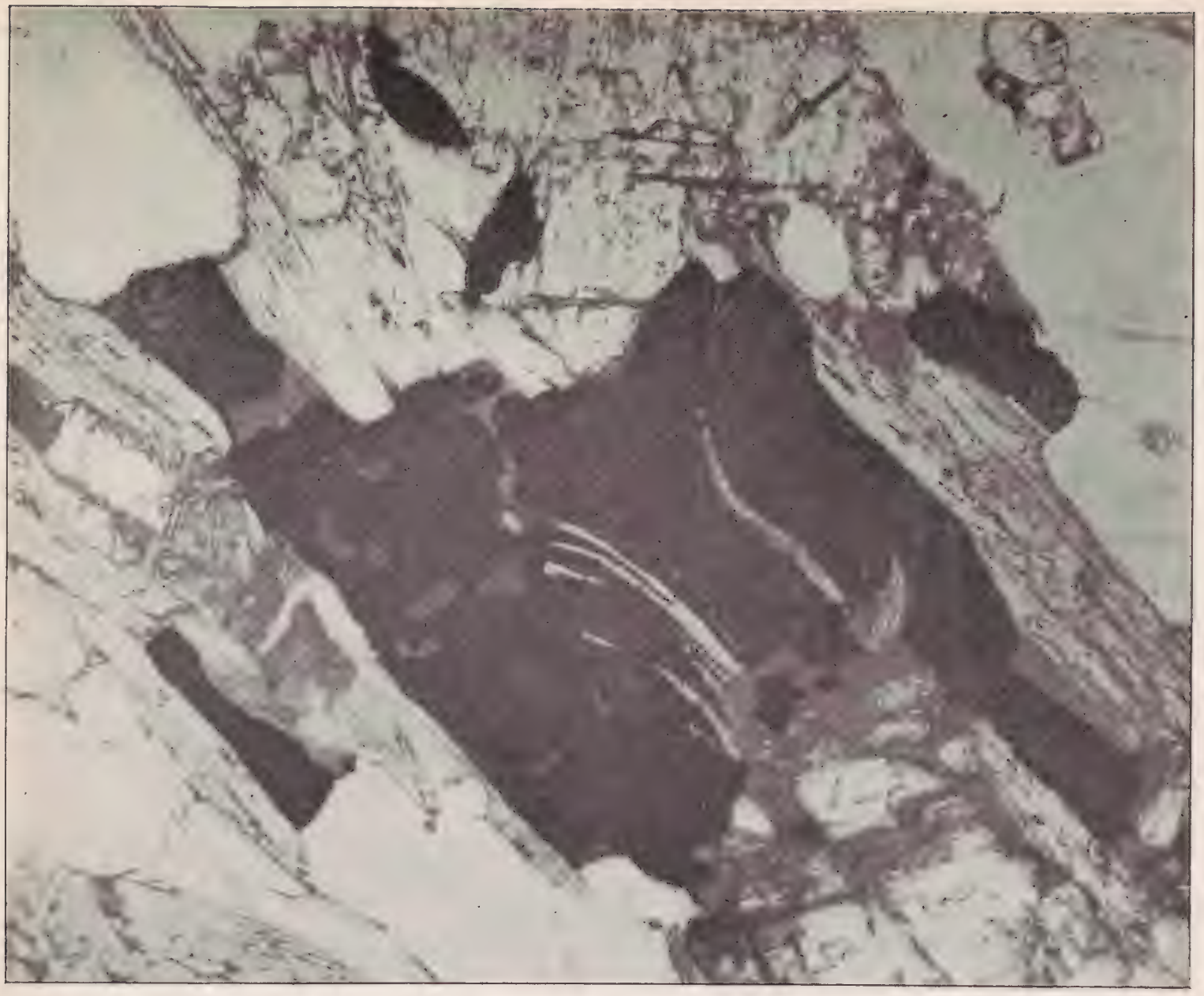

Fig. 22 Photomicrograph of foot-wall, Stella mine. Feldspar altering to green chlorite, which also fills cavities in lower part of pyrite. The latter has developed in slender, parallel tongues, between which sericite has formed. Pyrite is also shown in bleached mica and orthoclase. (Magnified 83.5 diameters)

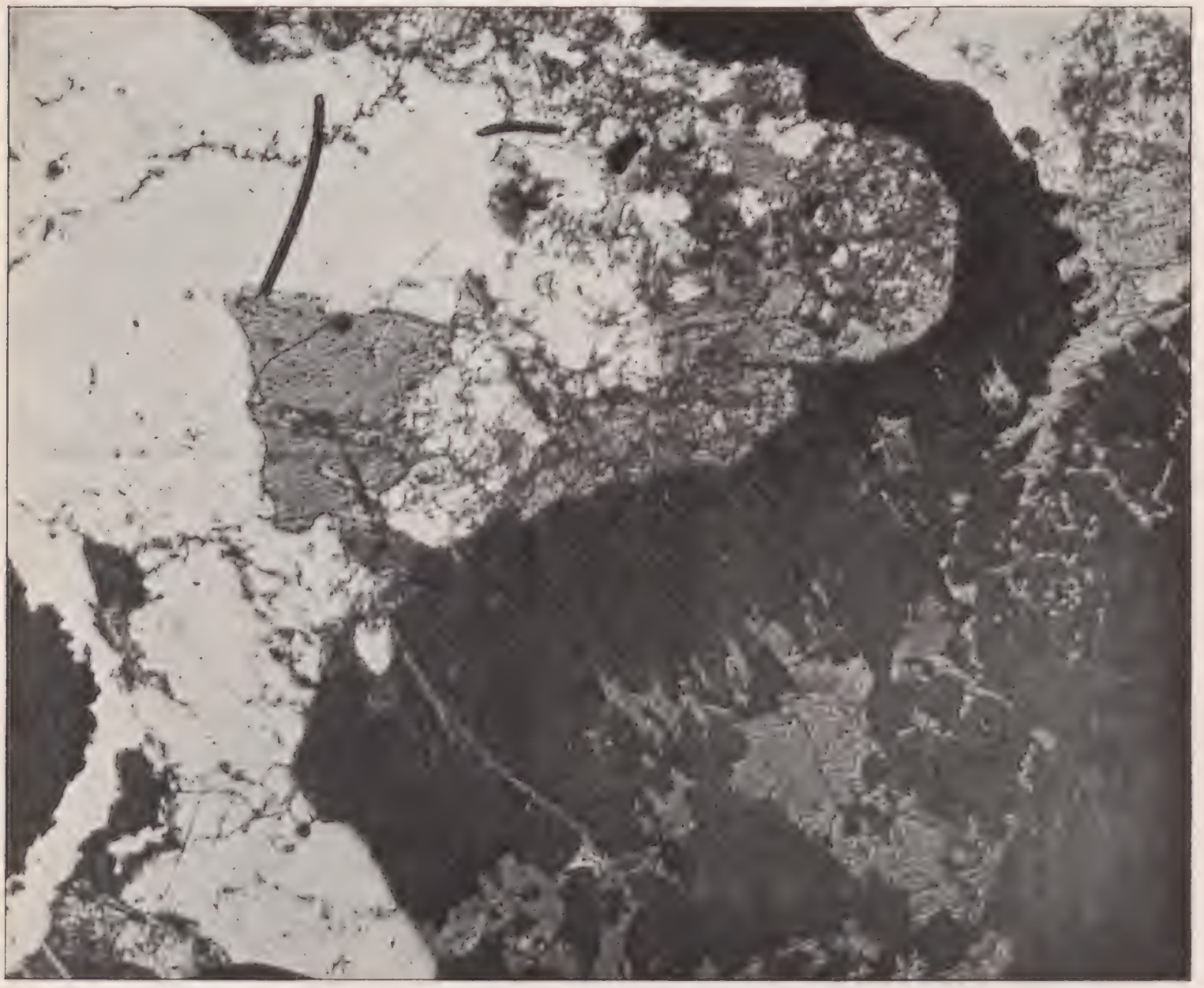

Fig. 23 Photomicrograph of pyritiferous pegmatite from foot-wall, Stella mine. Skeletal growth of pyrite in chlorite, which latter has developed chiefly at the expense of feldspar. (Magnified 27.5 diameters)

abundance of deep green chlorite which forms from both feldspar and hornblende but, so far as the evidence of a single section may be trusted, more from the former than the latter. This chlorite is fibrous and of a strong, deep green color persisting with crossed nicols which bring out aggregate polarization and weak double refraction. Pyrite in large masses is abundant, lying imbedded almost exclusively in the chlorite and molded upon hornblende and apatite instead of replacing them (see figure 24). The pyrite is frequently in slender branching aggregates which have grown in and been supported by the chlorite, and is clearly younger than the latter mineral.

As bearing upon the mobility of the chlorite, referred to in connection with previous sections, an interesting fact appears in this slide. At one point a very narrow crack has developed in a grain of pyrite, crossed an area of chlorite, torn it away from another grain of pyrite, and separated a corner of the latter. The crack throughout its course is sharply defined by narrow black boundaries and is completely filled with a later deposit of chlorite. The latter is the same deep green as the old chlorite and in ordinary light would not be distinguished from it but for the dark boundaries of the crack. With crossed nicols, however, the younger chlorite in the crack shows different optical orientation and so is sharply distinguished from the older mineral (see figure 25).

With this diagrammatic case before us it is easy to find many similar though less clear instances, and it becomes evident, as suggested previously, that the chlorite is very mobile, circulating relatively freely and thus tending to fill all spaces, however minute, in the rock. It is also clear that the several cases previously described where there seemed to be conflicting evidence as to the relative age of pyrite and chlorite are cleared up by this proof of at least two periods of chlorite formation, one before, the other after, the deposition of pyrite. As to the larger question of the date of pyrite concentration compared with that of the possible intrustion of the hornblendic rocks, an indication is given by the presence of clearly later pyrite masses in these rocks. That the same later date holds good for the larger ore bodies is probable, and this may account for the fact, already stated, that the ore deposits show no marked difference when compared with those not directly associated with similar rocks, but on the contrary agree in all essential features with the prevailing type as developed in the midst of extensive belts of Grenville sediments.

THE MINES AT PYRITES

At Pyrites, formerly called High Falls, pyrite was mined on a fairly large scale several years ago, but when visited by the writer the mines were idle and evidently had been so for some time. The locality is however of much interest and, standing alone, would be apt to lead to views quite unlike those presented in the sequel as to the origin of the ore bodies. Extensive exposures are afforded by the deep gorge of the Grasse river, at the lower end of which the pyrite is shown better than at any other locality visited. At this point a fine section is shown, the rusty gneiss being very strongly developed, dipping northwest at a high angle and striking northeast to north. A marked lens of pyrite about eight feet thick occurs in the gneiss, and the latter is itself permeated with pyrite. This lens with somewhat varying thickness extends to the top of a precipitous bank, but in the floor of the gorge pinches out abruptly along the strike. Veinlets of pyrite cut all the rocks including the ore lens itself, showing a certain amount of circulation late in the history of the formation, probably subsequent to all pronounced mechanical disturbance.

The rusty gneiss shows its usual contortions and abrupt changes of strike and dip, is strongly banded and foliated, and in every way appears to be sedimentary or, if igneous, is of extreme antiquity and has suffered most intense metamorphism with resultant obliteration of all original characters.

Immediately underlying the gneiss, with apparently conformable contact, is a rather massive, coarse, micaceous, nearly black rock, which is shown by exposures farther up stream to be a phase of the coarse gabbro so strikingly developed in the gorge above. While this rock is unquestionably later than the rusty gneiss, the contact between the two gives no suggestion of being an eruptive one, a fact difficult to explain (unless faulting be appealed to) but quite frequent in contacts between Grenville and later intrusive rocks throughout the region. The only thing suggesting the relations of the two rocks is the abnormal character of the gabbro at the contact as compared with exposures farther up stream, more in the heart of the intrusions. There is a decided contrast between the two rocks, but the character of that at the contact, though rather finer, is not such as to point clearly to contact modification. Thus, without the evidence afforded by other exposures, neither the nature

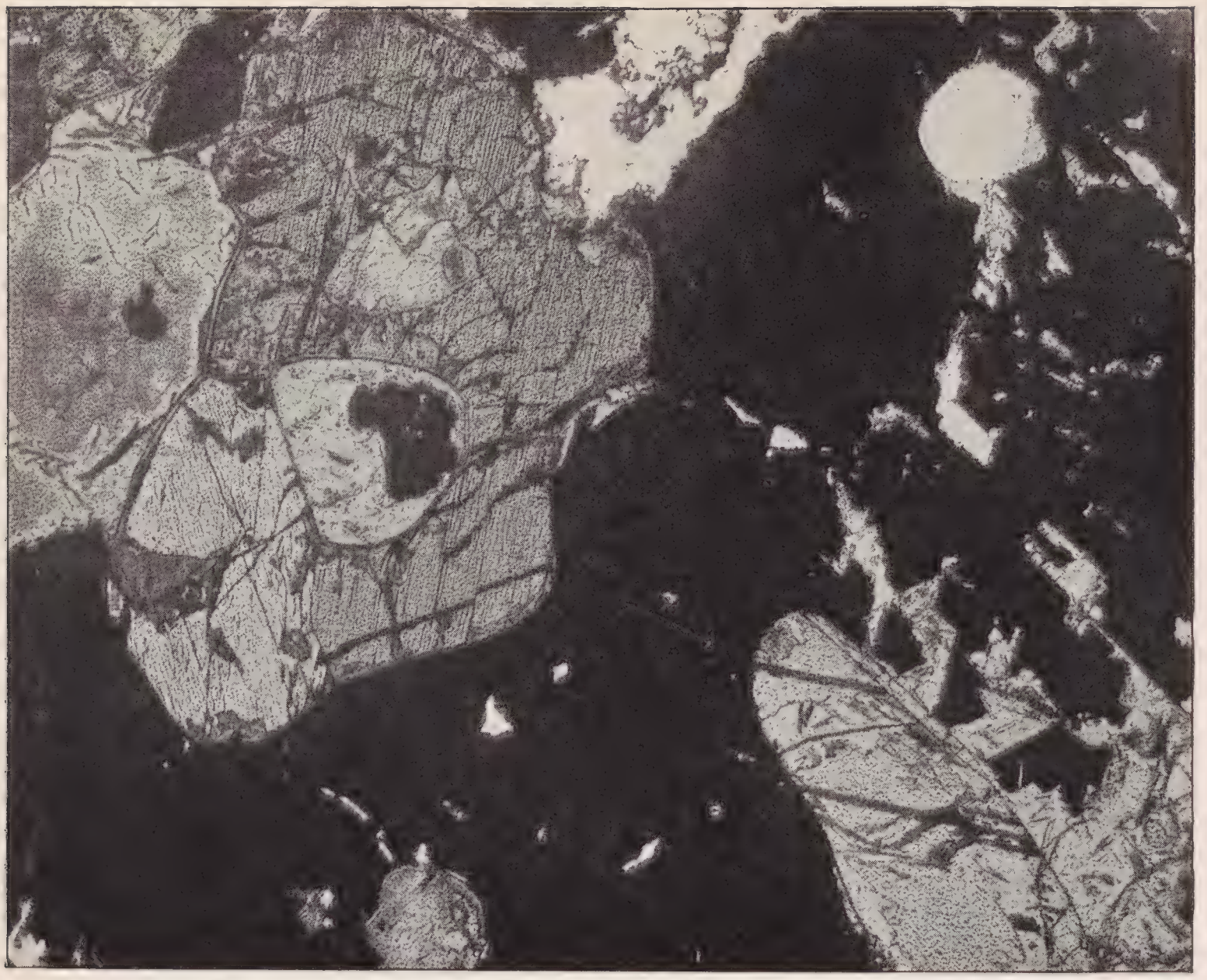

Fig. 24 Photomicrograph of pyritiferous hornblende gneiss, south of Anna shaft, Stella mine, with pyrite grown freely in chlorite, but molded upon hornblende and apatite. (Magnified 27.5 diameters)

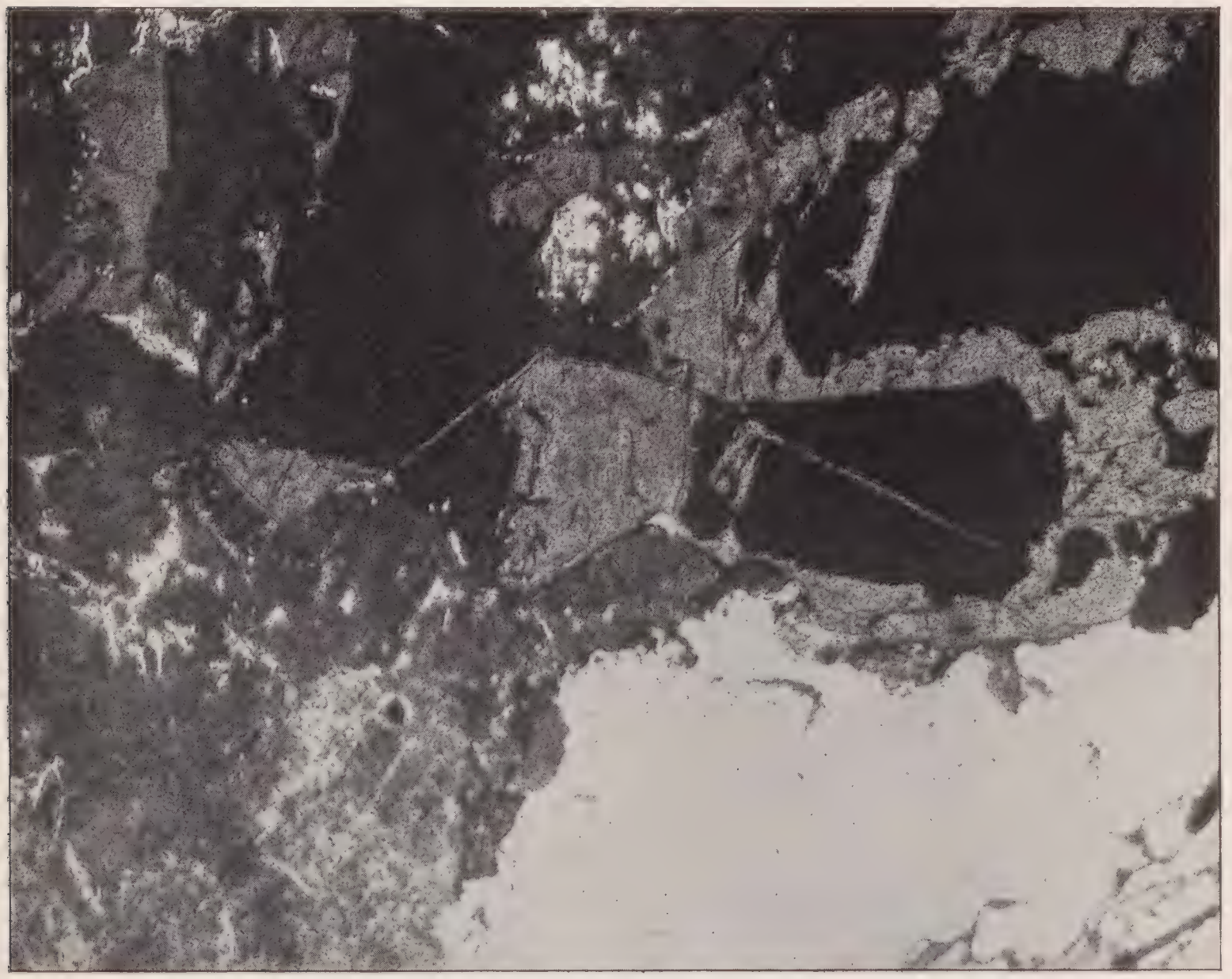

Fig. 25 Photomicrograph of pyritiferous hornblende gneiss, south of Anna shaft, Stella mine, showing pyrite developed in chlorite, with a crack passing through both, and filled with younger chlorite. (Magnified 27.5 diameters)

of the gabbro nor its relation to the rusty gneiss could be determined at this point. The section is diagrammatically shown in figure 26.

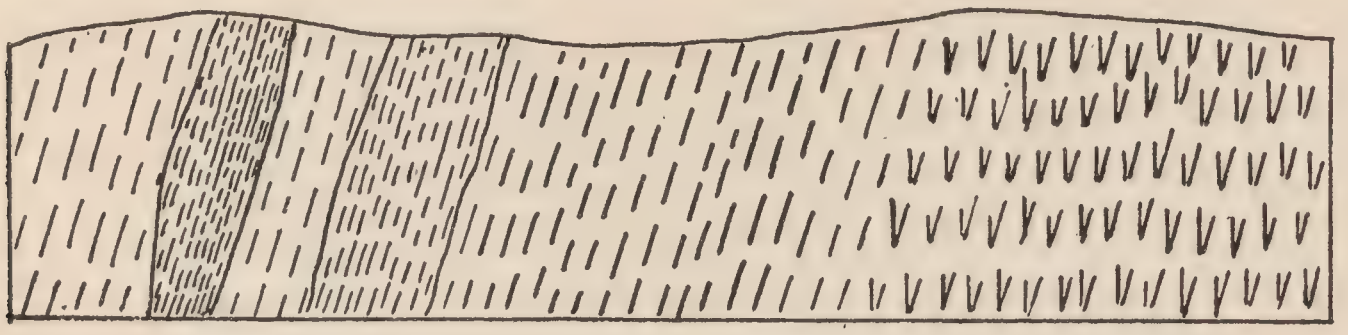

Fig. 26 Ore lenses more heavily shaded; gabbro hachured

A massive rusty gneiss with much pyrite, which might be classed as a second, but much lower grade ore body, underlies the main lens, with a small barren space intervening. As indicated in the diagram, it is thicker than the main lens, and much less sharply defined, while at the same time the pyrite is very unevenly distributed.

The gabbro above referred to is by far the most conspicuous rock of the section and is best shown at the paper mill about half a mile upstream from the first mentioned locality. The rock is very dark in color, sometimes almost black, varying from medium to very coarse in grain and from massive to strongly foliated. Abundant mica, with a suggestion of flattened orbicular structure, gives to some exposures a most peculiar aspect quite unlike that of any rock seen by the writer elsewhere in the northern Adirondack region. Farther upstream the rock becomes a rather coarse hornblende gneiss whose origin would be very obscure but for the fortunate exposure of the transitional belt between the two phases.

While in the field the rock is conspicuously hornblendic and micaceous rather than pyroxenic, thin sections of the more massive varieties show sufficient pyroxene to indicate the probability that this was the prevailing original ferro-magnesian mineral. For this reason the rock is regarded as a member of the widespread gabbros of the Adirondacks, rather than a somewhat pyroxenic diorite. The gabbro, in its gneissoid phase, is extensively developed in the vicinity and, while not yet mapped, covers some square miles. A considerable extension to the southwestward toward the Stella mines tends to support the conclusion, previously referred to, that the very similar hornblende gneiss at the latter locality may be in reality a phase of this same gabbro.

While at the lower end of the gorge at Pyrites the gabbro appears below the ore only, south of the paper mill it occurs also as a thin sheet above the pyrite formation, the main body continuing below. This is best shown at the lower end of a small island in the Grasse river just below the dam. Here the rusty gneiss, with abundant

pyrite, is exposed in the river bed with a width of about forty feet; on the east (below) is the main body of gabbro, while at the west (above) the same rock appears and continues to the west bank of the river where gray gneiss of Grenville aspect comes in. The accompanying diagram (figure 27) makes these relations clear. At the upper contact of pyrite and gabbro, and in the former, is a conspicuous pegmatite containing tourmalin, garnet in large and fine crystals, and much pyrite. At the upper end of the island a few rods distant, the gabbro is continuous where the pyrite formation should occur, the latter having been cut out by the intrusion of the former. This explanation of the absence of the pyrite formation is justified by the fact that unbroken outcrops on both sides of the island eliminate the possibility of an abrupt change of strike and at the same time render faulting improbable.

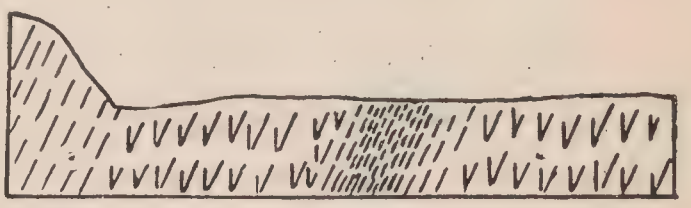

Fig. 27 Rusty gneiss and ore heavily shaded; gabbro cross hachured

From the foregoing description it is evident that the general impression given by Pyrites is very different from that afforded by the other pyrite localities. Instead of extensive outcrops of Grenville, with the conspicuous rusty gneisses, the great development of nearly black gabbro is the impressive feature; and in view of the general association of sulfid concentrations with gabbro, such an explanation is immediately suggested for the present case. Further support is given to this idea by the fact reported by Brinsmade[1] that a large body of pyrrhotite is associated with the pyrite in the mines.

The occurrence of the sulfids at the margin of an extensive intrusion of gabbro is certainly most suggestive of their concentration by magmatic differentiation while, assuming the hornblende gneiss at Stella mines to be part of the gabbro, a closely related method of origin might be inferred for the ore bodies of the latter locality. While much may be said in favor of this view, the writer is unable to accept it since, in spite of their intimate association with the gabbro, the ores at Pyrites actually occur as elsewhere in typical rusty gneisses, quite indistinguishable from those in which they occur at localities where gabbro is absent. For example, the exposures at the lower end of the Pyrites gorge shows rocks in every way similar to those at the Cole, Farr, Styles and other similar localities, while at the two shafts worked in recent years the material on the dumps can not be distinguished from that at other

[1] Brinsmade, R. B. Pyrite Mining in St Lawrence County, New York. Eng. and Min. Jour. Oct. 28, 1905, p. 770–71.

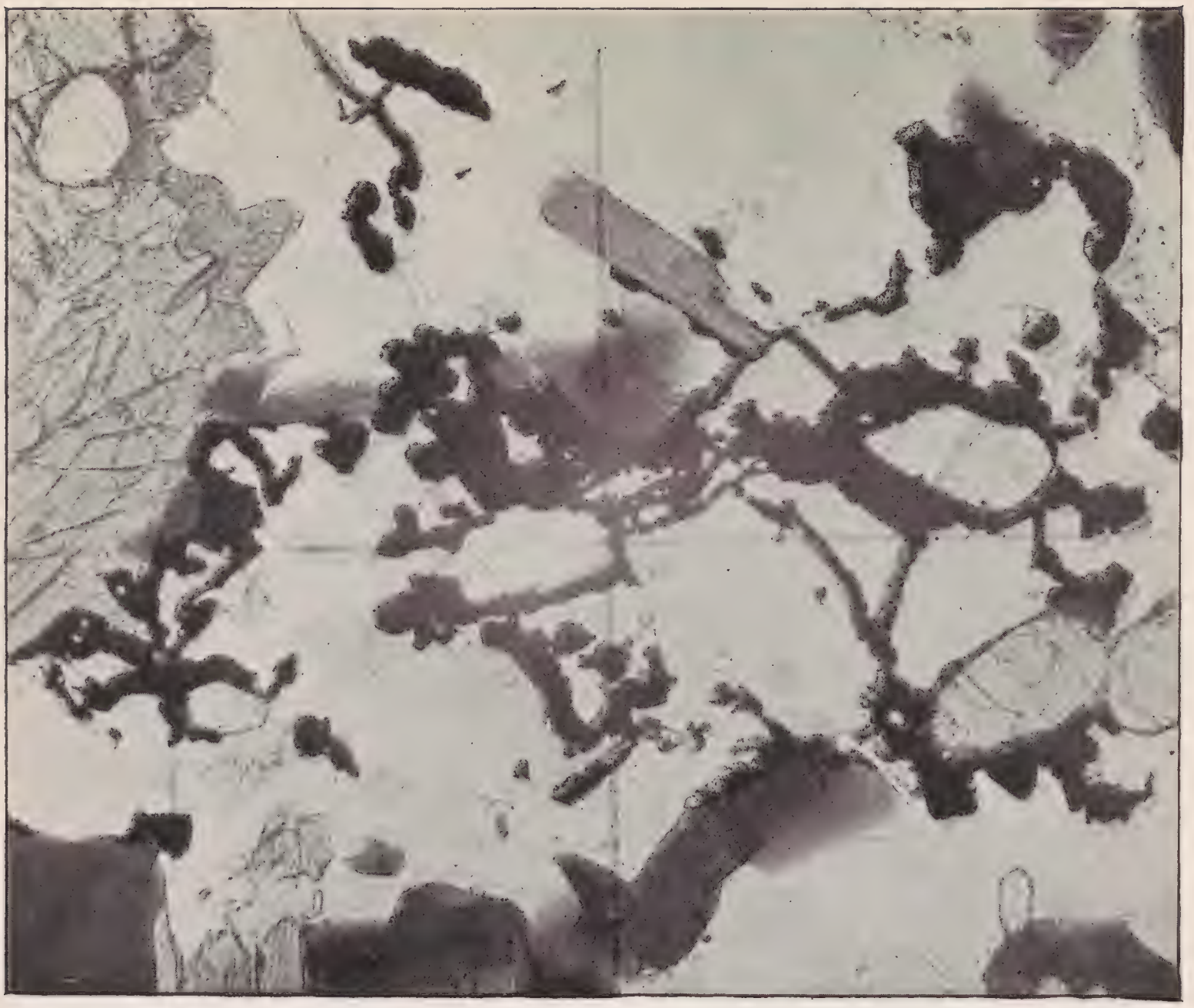

Fig. 28 Photomicrograph of gabbro associated with the ore at pyrites, showing an infiltration of pyrite replacing feldspar. (Magnified 83.5 diameters)

Fig. 29 Photomicrograph of lean ore, pyrites, showing pyrite replacing a single grain of plagioclase feldspar. (Magnified 83.5 diameters)

mines. Even where, at the lower end of the island, the pyrite has gabbro on both sides, the ore still occurs in the strongly laminated rusty gneiss rather than in the gabbro itself. As a matter of fact, very little pyrite occurs in definitely recognizable gabbro, and when present at all appears plainly to be a secondary infiltration, as illustrated by figure 28.

For these reasons, together with others to be mentioned later, it seems to be a necessary conclusion that the ore is not, even when closely associated with gabbro, a direct product of magmatic differentiation. On the other hand it is possible that solutions and vapors given off from the gabbro magma may have played a part in forming the ore deposits, although no positive evidence bearing upon the question is at present available and its further consideration is, therefore, best deferred till more extended data can be obtained.

A specimen of ore from the bed of the river consists of a very fine-grained, dark green, chloritic aggregate, with abundant graphite and rather evenly disseminated, irregular masses of pyrite. The thin section shows a quartz-feldspar-mica aggregate, with kataclastic structure, containing an abundance of graphite, light green chlorite and pyrite. The pyrite shows some skeletal structure with interspaces filled with chlorite. Though in itself of somewhat doubtful nature, the section closely resembles several from other localities which were, from the evidence given by the intermediate stages, regarded as formed by the alteration and replacement of Grenville mica gneisses. The dark color of the hand specimen might suggest a pyritiferous phase of the gabbro, but the microscope does not support this view and indicates that the color is due to the chlorite and the graphite. Another and very similar specimen, though almost as dark in color, is shown in a thin section to be very quartzose, but at the same time exceedingly rich in graphite together with a good deal of deep green chlorite. The quartz is much crushed and the chlorite has replaced it largely. The pyrite, in fairly large masses, shows few fractures and must have been deposited or recrystallized subsequent to the crushing. The original rock appears to have been a quartz schist.

A specimen from the dump differs from the above in being coarser grained and lighter colored, showing much quartz and mica and little graphite. Pyrite is abundant, evenly distributed and often in distinct crystals. The thin section shows very large areas of pyrite, green chlorite and bleached mica. The pyrite is somewhat cracked and recemented by secondary quartz. Indeed, it is quite possible that all of the quartz is of this origin. A single grain of plagioclase

shows a replacing network of pyrite (figure 29). Graphite is less abundant than in the preceding sections. By itself this rock is too much changed to show its origin, but comparison with others point to its probable derivation from a pegmatite or from a gneiss of the pyrite formation. The former origin is probable for a very coarse, quartzose ore from the dump with large masses of quartz probably of vein origin. The thin section shows a much altered quartz-feldspar-mica aggregate, with abundant fibrous yellowish chlorite and pyrite, a little graphite and garnet. Here the pyrite has often included small flakes of mica which, more or less altered, retain their outline very sharply. Graphite is not abundant.

A section of lean ore from the lower end of the gorge shows a quartzose gneiss with scattered grains of pyrite and the usual accompaniment of light green chloritic material. In this section there is little evidence of secondary introduction of pyrite and, standing by itself without reference to other examples, the pyrite would be regarded as, and probably is, a simple product of recrystallization during metamorphism. But instances of this kind are so uncommon as to make the prevalent relations of pyrite in the rocks more conspicuous.

It is clear from the above that microscopic study of the ores of this locality confirms the conclusion derived from field work that the pyrite can not be regarded as a product of differentiation in the gabbro magma. Between the two formations there is no close mineralogical relationship, while the ores agree in all essential respects with those of the other localities where gabbro is absent.

GENESIS OF THE DEPOSITS

From the foregoing brief statement as to field relations and microscopic character of the ore deposits, it is evident that the available data are inadequate to afford the basis of any complete explanation of their genesis. The many vicissitudes to which the pyrite-bearing formation has been subjected have lead to the obliteration of much evidence necessary to work out the successive steps in the process of pyrite concentration. Like the closely related "Fahlbands" and "Kieslager" of Europe, these ores belong to a complex class of deposits whose origin has always been a matter of doubt.

In dealing with such involved phenomena it is by no means easy to discriminate between the essential and the incidental, and yet there are certain features, common to all the pyrite occurrences studied, from which some certain definite conclusions and more or less probable inferences may be drawn as to the origin of the deposits.

Of these features perhaps the first that should be mentioned is

the distribution of the deposits, which has previously been referred to only incidentally.

When the pyrite localities are indicated on a map it is at once apparent that in a general way they conform to the prevailing northeast and southwest trend of the Grenville belts of the region, this trend corresponding approximately with the strike of the rocks. It should not be inferred, however, that the various mines occur along a straight line, for such is not the case, although the first four localities described do not vary widely from such an arrangement. This distribution of the deposits is the result of what may be taken as the second important feature to be mentioned, that is the constant association of the pyrite with Grenville rocks, which occur as long, narrow belts surrounded, and often broken across, by great areas of granite gneiss. This association of the pyrite with metamorphosed sediments rather than with the more extensive areas of igneous rocks, is a very striking feature of the deposits. Furthermore the association is not only with the Grenville but with a particular variety of the Grenville rocks, the so-called rusty gneisses, rocks which appear to be the products of metamorphism of impure sandstones and shales.

As to the possibility of the pyrite occurring not only in a certain kind of rock but in a certain definite horizon, a conclusion seems justified despite the dangers attending the use of ordinary methods of stratigraphy in dealing with the Grenville.

The Styles and Farr mines show such similarity of rock succession as to suggest the possibility of identity of horizons. The Hendricks pit, while showing limestone below the ore instead of having it above also, as these do, has a heavy thickness of gneiss. At the Cole mine scarcity of outcrops leaves relations uncertain, but this very scarcity indicates the absence of the heavy gneiss which overlies the ore at the Hendricks pit, though this latter locality is nearer the Cole than the others. At Stella the section is totally different in its details from all the preceding localities; the same is true of Pyrites, although here of course the great intrusion of gabbro would suffice to account for such dissimilarity. Combining these data, it seems necessary to conclude that the pyrite, though confined to a certain type of rock in the Grenville, is not limited to any definite horizon.

This occurrence of the pyrite in the one type of rock is another important feature of the deposit which must be considered in any hypothesis framed to account for its origin. In dealing with this phase of the problem there is a serious practical difficulty. All

rocks rich in pyrite weather with deep rusty brown and black stains, and very different rocks may, for this reason, be regarded as identical in the field. While fresh specimens often show differences at a glance, it is sometimes difficult to procure fresh specimens of such easily weathered rocks. Without having made any extended study of the so-called rusty gneisses, the writer has encountered two rather distinct types. One of these contains much pyroxene, hornblende, mica, feldspar, quartz, scapolite, a relatively large amount of titanite, some zircon, graphite and both pyrite and pyrrhotite. The minerals are often in rounded grains, and the rocks might be classed as pyroxene granulites. Though occurring in the Grenville, the origin of these rocks is obscure. Similar though more massive rocks, with much scapolite, have, as already stated, been classed as gabbros and were doubtfully placed in this category by the writer.

The rusty gneisses of the second type are of much simpler composition, having the ordinary minerals of acid gneisses together with graphite and pyrite, with interlocking crystalline texture. From the previous descriptions of the pyrite deposits it is obvious that they all occur in gneisses of the latter type, being portions of the rock exceptionally rich in pyrite. True, considerable variation of composition appears in the gneisses as described, but not enough to throw them into markedly distinct types nor any more than would appear in descriptions of an equal number of specimens of the ordinary Grenville gneisses. Perhaps the most pronounced peculiarity of the pyritiferous gneisses, particularly as contrasted with the pyroxenic rusty gneisses mentioned above, is their acidity, they being always very quartzose and in general lacking the minerals characteristic of basic gneisses. Even garnet and sillimanite, which might be expected in these metamorphosed sediments, are by no means common.

While it is true that the pyrite ore bodies are confined to this type of gneisses, it must not be forgotten that pegmatites present in the rocks also contain the mineral. The presence of these pegmatites is, moreover, one of the striking features of the deposits, for at no locality are they lacking. Whether or not they are more abundant in connection with the ore deposits than throughout the region as a whole, it would be difficult to say, but certainly they are no more abundant than at many points where no pyrite occurs. The pegmatite is often injected in thin layers parallel to the banding of the gneiss and so thoroughly blended with the latter as to make it

difficult or impossible to draw any line between the original and the injected material. The pegmatites themselves are derivatives of the great intrusions of granite-gneiss referred to above as surrounding and cutting through the Grenville, injecting it with every variety of intrusion from batholyths down to sheets of almost microscopic thinness. As shown in an early report,[1] where the intrusions become very thin they nearly always assume a pegmatic habit. This apparently anomalous behavior doubtless finds its explanation in the fact that only the more fluid portions strained off from the magma are capable of penetrating the narrow openings where, in virtue of their abundant gases and mineralizers, they naturally crystallize as pegmatites. It does not of course follow that no thick masses of pegmatite are present, since these are by no means rare, both types occurring with the ores.

It is hardly necessary to recall at this point the fact that the Grenville rocks are all completely metamorphosed by the combined action of orographic disturbances and igneous intrusions, under heavy cover. The tendency of the pyrite to occur as lenses, conforming in general with the prevailing dip and strike of the associated gneisses, in so far as it is the result of mechanical forces, rather than replacement of lense-shaped masses, is doubtless to be referred to disturbances subsequent to the period of intense metamorphism.

Among the more intimate features of the ore deposits mention should be made of the very general association of graphite with the pyrite, the former mineral occurring at all the mines, often in abundance though not evenly distributed through the ores. Thus while pyrite ores commonly carry graphite, this is not invariably the case. Conversely graphite, which is widespread in Grenville rocks, often occurs without pyrite.

Another feature of the ores is the nearly universal occurrence of a chloritic alteration product with the pyrite. This material is evidently derived from mica in some cases, but in others seems equally clearly to grow at the expense of other minerals, particularly quartz and feldspar. Such an alteration is by no means general in the Grenville rocks, but on the contrary appears to be the result of unusually potent chemical agents associated with the formation of pyrite.

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[1] Smyth, C. H., Jr. Report on the Crystalline Rocks of St Lawrence County. N.Y. State Museum, 49th Ann. Rept. for 1895, II, p. 491.

Finally, of the intimate features of the deposits, the most important is the relation which the pyrite bears to the other minerals present. So much has already been said upon this point that a brief summary will suffice here. While often occurring in rounded or irregular grains, whose relations to the other minerals are susceptible of various interpretations, the pyrite also frequently appears in shreds, strings and veinlets cutting the other minerals in such a way as to make evident that it is actually replacing them. There is a strong tendency for pyrite to develop its own crystal form quite independently of the surrounding minerals, and from cases of this kind there is every gradation up to large bunches of pyrite replacing the country rock. Such bunches occur scattered through the rock, united by strings and veinlets of pyrite, and as they increase in size and numbers gradually convert the rock into an ore. Associated with this replacement there is often the great development of chlorite referred to above, so that the ore becomes, as at Stella, a granular aggregate of pyrite and chlorite, the other minerals still present, with the exception of graphite, being pretty well masked by these two.

The time relation between pyrite and chlorite is not simple. As previously stated, pyrite often seems to crystallize more readily in contact with chlorite than with other minerals, suggesting that the chlorite was present first; but on the other hand chlorite sometimes fills cracks in pyrite and is therefore younger. However, this is a subsidiary phenomenon since the same chlorite fills cracks in an older chlorite, so that these cases prove nothing beyond the mobility of the mineral. The evidence as a whole indicates that, while closely related in time and origin, the pyrite is generally somewhat younger than the chlorite. Much less frequent, but not to be overlooked, is the development of sericite so related to chlorite and pyrite as to show that it is younger than these minerals.

To formulate a hypothesis that will unite and explain these various phenomena and at the same time harmonize with what is known to be true or probable in regard to the geology of the region, is by no means easy. Unquestionably the series of operations by which the ore deposits have been formed was exceedingly complex, the available data are meager, and the best that can be hoped is to get some clue to the more important agents involved.

Assuming the rusty gneisses to be of sedimentary origin, representing shales and impure sandstones deposited in the Grenville sea, a simple explanation of the pyrite is to regard it as a primary

chemical sediment deposited on the sea bottom, and thus originally interbedded with the other Grenville rocks. This would account for the association of pyrite with the gneisses rather than with crystalline limestones, in agreement with the familiar tendency of the mineral to appear in shales and sandstones rather than limestones. Furthermore the tendency in later rocks, as well as in modern muds, for pyrite to occur in such as are rich in organic matter, finds in the present instance a parallel in the association of pyrite with graphite. This association is quite general for the rusty gneisses and is very striking at the Cole and Stella mines, as already pointed out. Altogether, a consistent explanation of the rusty gneisses and accompanying pyrite seems, at first sight, to be afforded by regarding them simply as metamorphosed pyritiferous and carbonaceous shales and sandstones.

From an explanation so seductively simple it is difficult to turn, and the writer is of the opinion that, with present evidence, there is much in favor of this view so far as the ordinary rusty gneisses with a little disseminated pyrite are concerned. But in applying the hypothesis to the larger masses represented in the ore deposits, difficulties arise. Here we come in contact with marked concentrations of pyrite, in veinlike masses, pods and lenses, often very thick, with much vein quartz and pegmatite containing both pyrite and graphite, the whole presenting little resemblance to sedimentary deposits. Obviously some of these phenomena are entirely outside the realm of sedimentary agencies and there appears to be ample ground for ascribing most of this pronounced concentration to a later period of circulation, involving a large amount of transfer of material and replacement.

In view of the well-known tendency of pyrite to circulate and segregate in sedimentary rocks subjected to the action of ordinary ground waters it is quite possible that the process of concentration was begun in this way before the rocks were metamorphosed, and Newland[1] regards such premetamorphic concentration as probably of dominant importance. The complete recrystallization of metamorphism would, of course, destroy all the original structural relations between pyrite and the clastic minerals which would show whether the former was original or secondary, and thus after metamorphism it would be impossible to distinguish with certainty between pyrite of sedimentary origin and that resulting from ground water concentration, except as the latter might occur in

[1] Loc. cit.

masses of such form and magnitude as to be difficult to reconcile with a sedimentary origin, as is true in the present instance. Thus it is entirely possible that pyrite deposits might be formed by both of these processes, and be quite indistinguishable after metamorphism sufficiently intense to involve complete recrystallization.

That any considerable concentration of pyrite was effected by the metamorphism is improbable. The process doubtless resulted in a crystallization of the minerals already present in the rocks with no decided change of ultimate chemical composition. Original pyrite would be recrystallized, and where the proper materials and conditions existed, new pyrite would be formed, just as other minerals were formed throughout the whole mass of rocks from materials already present. All of this pyrite, both recrystallized and newly formed, would bear to the other minerals of the metamorphic rocks relations similar to those which these latter bear to each other. In other words, the pyrite would appear as a perfectly normal and essential constituent of the rock, taking part in its regular crystalline texture. Some of the thin sections examined show this relation, and doubtless if many sections of gneiss with scattered grains of pyrite were examined the relation would be found to be quite general. But from the descriptions of sections of the ores already given, it is quite apparent that in these most of the pyrite bears a very different relation to the metamorphic minerals, indicating its deposition as being subsequent to, rather than simultaneous with, their formation. In so far as this is the case it is evident that the ores are neither original sediments nor premetamorphic replacements; and there is much evidence justifying this conclusion. In particular, the widespread chloritic alteration of the gneisses associated with the ore deposits, the very close connection between this alteration product and the pyrite, the late deposition of the latter mineral, so evident in many cases, replacing the minerals produced by the general metamorphism and often crystallizing in the chlorite secondary after these, the frequent abundance of vein quartz as a gangue, and the presence, in many cases, of pegmatite containing much pyrite replacing the primary minerals, are all phenomena, any one of which might perhaps be reconciled with the hypothesis of original sedimentation or of premetamorphic replacement, but in mass weigh heavily against them. Whatever the original source of the pyrite, these phenomena point to its relatively late concentration, subsequent to the period of extreme metamorphism.

If this conclusion is justified it follows that the ore bodies were

formed by the action of circulating solutions, which either concentrated into large masses, pyrite already present in a disseminated condition in the rocks, or introduced the mineral from an outside source. Manifestly these two sources of pyrite are in no way antagonistic and may both be of importance. Nor is it necessary to suppose that the pyrite is derived directly from iron sulfid of either origin, since it may, in part or wholly, result from reactions converting totally different compounds into sulfid.

All of the phenomena point to conditions quite different from those prevailing during metamorphism, involving the destruction of metamorphic minerals, but still, doubtless at such depth as to give temperatures and pressures considerably above those at the surface, and with circulating hot water, either magmatic or meteoric, as the active transporting agent. Between these two sources of the solutions there is no way of deciding finally, since solutions of either origin would probably be capable of effecting all the changes observed in connection with ore formation. Of minerals pointing certainly to igneous sources, only tourmalin is frequent in the ores, and this antedates much of the pyrite. Still, the mineral alterations in the rocks and ores are such as to suggest, strongly, the work of magmatic waters and, this being the case, with igneous intrusions so abundant throughout the region it is probable that magmatic solutions played a major part in the processes of ore concentration.

A formation that has been so thoroughly injected by igneous rocks and soaked by magmatic solutions and vapors might naturally be expected to show much concentration of metaliferous materials, and the probable explanation of their comparative scarcity is to be found in the fact that the existing surface rocks were, at the time of these activities under heavy cover, up into which the more mobile elements were carried to be subsequently removed by erosion, leaving the more abundant and stable substances, chiefly iron compounds, in the deeper regions now exposed. In so far as the pyrite is of sedimentary origin, it is probable that its migration and concentration may have been in part due to these magmatic agencies which must have permeated the Grenville rocks during prolonged periods. At the same time there may have been a contribution of pyrite derived from magmatic sources. In the field there seemed to be strong evidence for this latter view in the general occurrence of pyritiferous pegmatites associated with the ores, and it was thought that these might be regarded as important bearers of pyrite,

perhaps indeed the chief source. But, as already stated, microscopic study shows that the pyrite of these rocks replaces the other minerals, particularly the feldspar, and thus is secondary.

While it is evident therefore that the pegmatites are not the direct source of the pyrite, there is much reason for believing that their association with the ore deposits and their presence throughout the Grenville in such abundance, as well as the other evidences of extreme igneous activity point to magmatic sources for ore-forming solutions. Magmatic emanations permeating the gneisses would certainly appear to be the most probable agents to bring about the deposition of pyrite, replacing the older and usually very stable minerals.

The absence of contact and fumarole minerals approximately contemporaneous with the pyrite indicates that the latter was formed late in the history of igneous activity, when instead of the very potent fluorine, boron and chlorine compounds, hydrogen sulfid which marks a declining stage of igneous activity, was the dominant agent. Thus the pyrite probably was deposited after active intrusion of the magmas, from which it was indirectly derived, had ceased, and during a prolonged period of relatively gentle circulation of magmatic waters. To these agencies may be ascribed not only the deposition of pyrite but the closely associated formation of the peculiar chloritic alteration product, which is so characteristic of the ore deposits and of the less abundant sericite.

It is evident that magmatic agencies might operate in two ways to bring about the observed results, namely by concentrating pyrite already present in a disseminated condition, and by introducing entirely new pyrite of magmatic origin. These two processes would work together and combine to build the ore deposits. But it is probable that an intermediate operation may also have been effective, one constituent of the pyrite, iron, being already present as an original constituent in the rock, and the other, sulfur, supplied by the magma. Bleaching of the mica is a characteristic feature of the conversion of gneisses into ores, indicating the removal of iron from this constituent. Some of this iron reappears in the chlorite, but the latter is itself nearly always of a conspicuously pale tint, indicating low iron.

While the elaborate series of analyses needed definitely to establish the fact is lacking, it appears to be true that most of the iron originally present in the essential minerals of the gneiss, is now combined with sulfur to form pyrite in the ores, and if the pyrite

were entirely removed the residue would be much lower in iron than was the original rock. While mica is the only mineral to which the iron of pyrite can be definitely traced, it is quite probable that other iron compounds, such as garnet, magnetite and amphibole may have been sources of the metal which have undergone complete decomposition. It is an interesting fact that no magnetite has been noted in any thin sections, suggesting its complete conversion into pyrite.

This introduction of magmatic H_2S is thought to have been a potent agency in the production of the ores, but obviously the mere conversion by this agent of original iron into pyrite could not produce the ore bodies unless the original rock was very rich in iron compounds. That such may have been the case is entirely possible, and this may account for the localization of the ore deposits. But it is much more probable that the circulation that introduced the H_2S, with consequent formations of pyrite, also effected a concentration of this mineral with the consequent formation of the existing ore deposits.

In this connection there naturally arises the question as to why the pyrite, if not a primary precipitate, should be confined to a certain phase of the sedimentary formation, and this not the most soluble or easily replaced phase. One reason for this doubtless is, as just suggested, that magmatic sources supplied the sulfur of pyrite, the iron being an original constituent of the sediments. On this assumption the ore deposits would necessarily form in the gneisses derived from the shales and sandstones, which would be the iron-bearing members of the sedimentary formation, rather than the limestones. All other conditions being the same, and H_2S circulating through limestones to the same degree as through the metamorphosed shales and sandstones, there can be little doubt that any pyrite thus formed would be chiefly confined to the latter rocks for the simple reason that they alone would contain the iron necessary to combine with the sulfur to form pyrite. Pyrite so formed together with such original pyrite as may have been present, would tend to cause precipitation and further concentration in these rocks of pyritic materials of wholly extraneous origin, brought in by the circulating solutions. In this way the magma might furnish not only sulfur but iron as well.

While the concentration of pyrite in the gneisses rather than in the more soluble and chemically active limestones is thought to have been effected partly in this way, other factors have doubtless worked in the same direction. As already stated, the folding of the Gren-

ville took place in part under such conditions of load that the limestones and the gneisses behaved very differently, the former flowing like putty, while the latter were often greatly fractured. Doubtless this fracturing came at a time subsequent to the general metamorphism of the rocks, with decreased cover; and as it is under these conditions that the ore deposits are thought to have formed, it follows that the active solutions would have found much readier channels of circulation in the fractured gneisses than in the soft and putty-like limestones. This is regarded as an important, if not the chief, cause of the localization of ore deposits in the gneisses.

That the two types of rocks in question actually did afford such different conditions affecting circulation is clearly indicated by their relations to intrusions of the magma itself, and particularly such portions of the latter as are most closely related to magmatic solutions. On the one hand, as before stated, the gneisses and schists are repeatedly converted into injection gneisses, soaked through and through by granitic material often with highly developed *lit-par-lit* structure. Such injected material is often very acid, and pegmatitic on a small scale, and the sheets may be exceedingly thin. In other cases the gneiss is reduced to tiny fragments entirely surrounded by injected material. All the phenomena point to a very high degree of fluidity in the injected magma, approaching closely to the mechanical condition of the pyrite-forming solutions. In the limestones, on the other hand, such injection phenomena are rare, if they ever occur, all intrusions being comparatively massive in character. The contrast is striking and points clearly to the difference in the two types of rocks, as regards their reaction to pressure, as its cause. That the same effect would be produced upon the somewhat later circulation of magmatic waters forming the pyrite, is a natural and justifiable conclusion.

The possible function of graphite in the concentration of pyrite is a most obscure problem and its adequate treatment would greatly transcend the limits of this paper, involving as it does two distinct questions — the origin of the graphite, and its power to precipitate pyrite under the conditions present. As to the former question, in rocks of such antiquity affected by profound metamorphism and intense igneous activity, the writer would be more inclined to judge of the origin of the graphite from the nature of the rock containing it, than to regard the rock as sedimentary because it carries graphite of supposed organic origin. In the present instance, the pyritiferous formation as a whole is for many reasons regarded as sedimentary

and the assumption of the organic origin of the generally disseminated graphite is therefore well grounded. Even when graphite occurs in the pegmatites it may perhaps have been absorbed from sediments through which the pegmatites have passed. However, where graphite occurs in igneous rocks, the writer feels that the burden of proof rests with those who claim for it an organic, rather than a magmatic, origin. Doubtless most if not all of the carbon of sediments is ultimately of magmatic origin, and while it may become reincorporated in igneous rocks after passing through the atmospheric and organic stages, no reason is apparent why it may not also remain in the magma to appear not only in the compounds liberated by heat in the laboratory but as primary graphite. Many instances[1] are on record where no other source seems probable. But where, as in the present case, relatively small intrusions, carrying graphite, cut sediments in which this mineral is quite generally disseminated, absorption of graphite by the intrusions seems reasonable. Such absorption, however, implies mobility on the part of the graphite that might lead to considerable circulation and concentration, and raises the question whether the graphite, so abundant in some of the ores, was actually formed *in situ* by metamorphism of organic matter, or is in part or wholly a product of secondary concentration. So far as some of the ores are replaced pegmatites, this question does not of course arise, since any graphite present in these rocks must, if of organic origin, be a secondary introduction; but in the ordinary ores formed from gneisses it is of moment. Thin sections give no positive information on the matter, although in several instances some of the graphite appears to be younger than pyrite, implying the secondary introduction of the former. However, the evidence is capable of a different interpretation and thus not final. Vein quartz sometimes carries graphite and pyrite so related that their late and practically contemporaneous origin seems necessary. This shows that circulation of graphite has occurred in connection with the formation of ores, and it is probable that this circulation has resulted in con-

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[1] Weinschenk, E. Mémoire sur l'histoire du graphite. Compt. rend., VIII Congr. Géol. Internat., 1900, Paris 1901, p. 447.

Clarke, F. W. Data of Geochemistry, Bul. 330 U. S. Geol. Survey 1911, p. 311.

Winchell, A. N. Theory for the Origin of Graphite, etc., Ec. Geol. VI, 1911, p. 228.

Horwood, C. B. The Mode of Occurrence and Genesis of the Carbon in the Rand-Bankets. Trans. Geol. Soc. South Africa, 13, 1911, p. 65–92.

centration of graphite as well as of pyrite. In this connection, much interest attaches to Young's recent conclusion[1] that the graphitic carbon, relatively abundant in a few of the mines in the Rand conglomerates, is not of organic origin but is derived directly from magmatic vapors. Young is dealing with conditions which are similar to those that must have prevailed in the Grenville rocks prior to the period of intense metamorphism when a certain amount of concentration of pyrite may have occurred, as already indicated. Any magmatic carbon introduced at that time would evidently be indistinguishable now from carbon of organic origin, having been completely recrystallized by metamorphism. Thus, for the graphite, a history somewhat similar to that of the pyrite is indicated, but with the difference that most of the former is thought to be carbon that was original in the sediments, which has undergone some concentration and may have received minor additions from magmatic sources, while, in the case of the pyrite, the relative importance of these sources is reversed.

As to the relation of graphite to the precipitation of pyrite there can be no doubt that the original organic matter, from which the graphite was formed, was a potent agent both during sedimentation and any subsequent ground water concentration of pyrite. In the postmetamorphic stage, to which the main concentration of pyrite is ascribed, any precipitating effect would be due of course not to organic matter but to graphite. The oft-quoted instance of such precipitating action of graphite at Freiberg described by Von Cotta[2] has been supplemented by many other cases, and recently Jenny[3] has cited several examples. On theoretical grounds the action can be regarded only as a question of pressures and temperatures, and with these properly adjusted there can be no doubt that graphite would act as a precipitating agent. But so little is known, on the one hand, as to what pressures and temperatures would permit the necessary reactions and, on the other, as to the pressures and temperatures under which the pyrite was formed that little is to be hoped for in the present case from these general theoretical considerations. But with such a precipitating action possible, the marked association of graphite with the pyrite is, to say the least, very suggestive, and the former being regarded as representing a

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[1] Young, C. R. Trans. Geol. Soc. South Africa, XIII, 1911, p. 105–6.

[2] Von Cotta. Treatise on Ore Deposits, English Trans., p. 46–47.

[3] Jenny, W. P. The Chemistry of Ore Deposition, Trans. Am. Inst. M. E. XXXIII, 1003, p. 455–57.

primary constituent of the sedimentary gneisses, another reason appears for the concentration of the pyrite in these particular rocks, they being rich in graphite. Even were the precipitating action limited to the original organic matter from which the graphite is derived a similar though less important effect would result, since the presence of premetamorphic pyrite would favor the later deposition of pyrite in the same rocks.

But while the relation of pyrite and graphite can hardly be considered as other than in some way genetic, the writer is not convinced that it is as simple as above suggested and feels that further investigation may prove that the graphite, like the pyrite, has a very complex history, the two minerals having grown, in part, simultaneously, but the development of the former beginning before and ending after that of the latter.

So far as the distribution of the pyrite deposits bears upon the suggested hypothesis as to their origin, the lack of knowledge of the areal geology of the region prevents any detailed discussion. While viewing the deposits as chiefly due to magmatic agencies, the explanation offered postulates no close association in space between the ores and the intrusive rocks. On the contrary, the phenomena are thought to point distinctly in the opposite direction, the deposits being conspicuously unlike those due to contact metamorphism. The fact that igneous rocks are generally distributed throughout the region, so that no point in the Grenville can be beyond the reach of solutions derived from these, affords the necessary basis for the explanation appealed to, and thus marked areal relations between ore deposits and intrusive rocks are not to be expected. The distribution of the deposits is therefore controlled primarily by the distribution of the Grenville, which explains their linear arrangement.

A secondary control by large structural features, such as faults and shear zones, is probable, but much further study of the whole region is needed before any decision upon this point can be reached.

With reference to the type of igneous rock with which the pyrite is to be regarded as genetically associated, a tentative conclusion is justified. The intimate association of the pyrite at Pyrites with gabbro and the possible occurrence of the same rock at Stella mines, together with the very general genetic connection between iron sulfids (though as a rule pyrrhotite rather than pyrite) with basic rocks strongly suggest such a connection in the present instance. But a serious difficulty stands in the way of the acceptance of this view.

The gabbro, though extensively developed in the region immediately surrounding Pyrites, and extending well over toward, if not to Stella, is not a common rock elsewhere in the region, and so far as known does not occur anywhere in the vicinity of the other pyrite deposits. If, therefore, the present knowledge of the areal geology of the region may be trusted, it seems necessary to conclude that the gabbro is quantitatively insufficient to explain the origin of the pyrite as a whole though perhaps of importance in the two localities named. On the other hand, granites, both massive and gneissoid, with pegmatitic and other modifications, are everywhere abundant, and if magmatic agencies play the rôle that has been assigned to them there can be no doubt that their source must be sought in the granitic reservoirs.

Not only is this conclusion demanded by the general distribution of the igneous rocks, but it is strongly indicated by the actual occurrence of pegmatites in all the ore deposits and also by the abundance of vein quartz similar to that often associated with the granite and pegmatites of the region. It is then in the granite magma that a source is found for the heated solutions rich in H_2S and doubtless containing other chemical reagents, and iron, and it is to the circulation of these solutions in the gneisses and schists that the concentration of the ore bodies as they now occur is ascribed. As before stated, however, deeply circulating meteoric waters would probably be capable of producing the phenomena observed. Igneous agencies are invoked on the general ground of their high efficiency and on the special ground of their abundance in the region as a whole and the constant presence of their products in association with the ore deposits.

The conditions under which the deposition of pyrite took place are regarded as, in essence, similar to those prevailing in the formation of fissure veins, in so far as these latter are replacements of the wall rock. In this connection much interest attaches to the following quotations from Lindgren's exceedingly valuable paper on "Metasomatic Processes in Fissure Veins."[1] "Of all the sulfids occuring as metasomatic minerals, pyrite is naturally the most common. The mineral has a remarkable tendency to crystallization when developing in the rock, as contrasted with its often massive texture when occurring as a filing of open spaces. The forms assumed are either cubes or pentagonal dodecahedrons, or a combination of both. Pyrite develops in nearly every one of the ordinary constituents of rocks. By

[1] Lindgren, W. Trans. Am. Inst. Min. Eng. 30, 1900, p. 578–692.

preference, it forms in the new aggregates of sericite, carbonates and chlorite so common in altered rocks; but it also occurs in the fresh original minerals of the rocks, as in quartz, feldspar, horneblende and pyroxene. It is common to find small, sharp crystals embedded, for instance, in perfectly clear quartz grains, which show no break in their optical orientation around the secondary crystal, proving that the genesis is by purely metasomatic processes, and not, as may be advocated in the case of crystallization in soft aggregates, by the mechanical pressure of the growing crystal" (page 615). "The pyrite crystals are often bordered by a small rim of calcite or quartz; and little bunches of sericitic fibers may adhere to them, when forming in quartz" (page 616). Of chlorite he says, "This mineral, replacing amphibole, pyroxene and biotite, is commonly found in altered vein-rocks, but ordinarily is only a transition form, often abnormally rich in iron, which these minerals assume under the influence of waters slightly charged with carbon dioxid before their final conversion into sericite and carbonates. The chloritic alteration is most important in the group of the propylitic veins. Under the influence of strong alkaline carbonates and carbon dioxid, chlorite can probably not exist" (page 610). Later he quotes Rosenbusch on the development of the propylitic facies involving "a considerable development of sulfids," and says, "The waters principally active during the formation of the propylitic veins probably contained only a small amount of carbon dioxid and very little lime, but may have been rich in sulfuretted hydrogen" (page 645). Finally, in summarizing he says, "I believe that the majority of fissure veins are genetically connected with bodies of intrusive rocks, even when the actual deposits are contained in overlying surface lavas" (page 691).

The descriptive portions of these passages might be applied with little change to the pyrite, chlorite and sericite of the deposits under consideration, and although propylitic alteration is a feature of surface flows, it seems to shed light upon the deeper seated operation here dealt with. In both cases waters heavily charged with H_2S are the active agent, and pyrite is an important product. The accompanying chlorite is considered by Lindgren to be unstable in the presence of much carbon dioxid, altering to sericite and carbonates. In the present case, deficiency of carbon dioxid doubtless accounts for the relative stability of the chlorite, although at one point, the Hendricks mine, the process has gone to completion, with the formation of sericite, calcite and quartz. Thus in the pyrite

deposits there are several essential features which closely resemble phenomena shown in the wall rocks of fissure veins, where they have suffered alteration as a result of the attack of the vein-forming solutions, derived generally from magmatic sources. Without putting too much stress upon the similarity of phenomena, it is regarded as giving additional support to the hypothesis here advanced.

But while presenting this interpretation of the observed facts as worthy of careful consideration, the writer wishes again to accentuate the great complexity of the region as a whole and the consequent obscurity of the particular problem in hand. To ascertain all the factors entering into such a complex problem and to give them their proper relative weight is a difficult task, and the writer is by no means sure that he has succeeded in the attempt. The evidences of relatively late circulation and crystallization of pyrite and the associated chlorite and sericite have perhaps been given too much prominence and should be regarded as minor phenomena. The very agencies to which such potency has been ascribed might as a result of this potency completely rearrange pyrite already present in the rocks and thus destroy the evidence of its early formation. This mobility of pyrite is a very serious difficulty in the whole problem.

In summing the matter up on the basis of present data, it appears to the writer that four periods of pyrite formation are probable: (1) A primary precipitation of pyrite contemporaneous with the formation of the sediments; (2) a concentration of this pyrite by circulating ground waters, with the addition, perhaps, of pyrite of deep-seated origin, before the period of metamorphism; (3) but of minor importance, a recrystallization of all pyrite, accompanied perhaps by a certain amount of formation of new pyrite during metamorphism; (4) a further development and concentration of pyrite by magmatic agencies, perhaps working in combination with ground waters, as outlined above, following the period of active igneous intrusion and metamorphism. The first of these periods is suggested by the pyrite so generally disseminated through Grenville rocks, although even this could of course, in view of the widely disseminated intrusions, result from the operations of the fourth period. The reasons for accepting the latter have been given at length, while the second period is purely hypothetical, being based merely on the marked tendency for disseminated pyrite to be concentrated by ground waters and the frequency with which the mineral is brought up from deep-seated sources. Nevertheless, though hypothetical, it is thought that this process is likely to have

led to more pronounced concentration than was effected by primary sedimentation. In both processes organic matter, the residue of which appears as graphite, would be an active agent. Deposits of either origin would of course during metamorphism undergo recrystallization, together with the other constituents of the sediments, accompanied by little if any concentration. Pyritiferous gneisses and schists would result, but obviously the pyrite would not bear to the other minerals the relations that it has been seen to bear in the ores. True enough, some sections, as already described, have pyrite that appears to be an essential part of the gneiss, and this is doubtless of the earlier origin and metamorphosed, but it is so rare that an extensive postmetamorphic recrystallization *in situ* is demanded unless much of the pyrite is, as here argued, of this later period of formation. Between the two hypotheses, the latter is deemed more probable.

While the suggestion of four periods of concentration of pyrite, under diverse conditions, may be thought to indicate a degree of complexity not demanded by the facts, and perhaps even improbable, it must be remembered that the ore deposits belong to a type that is essentially complex and occur in a region that is complex. These are facts to be reckoned with, and it is believed that no simple explanation will meet the existing situation. Indeed, the writer is convinced that what is here presented constitutes the barest outline of the actual series of processes involved in the genesis of the ores, a series which, if it could be worked out in complete detail, would doubtless afford a bewildering assemblage of phenomena.

Pyrite is a mineral capable of forming and existing under a great variety of conditions. Its constituents are abundant and circulate freely, favoring much diversity and complexity in methods of concentration. Granted the primary deposition of some pyrite in the original sediments (and such an assumption is conservative) the general geological relations of the region, together with the details of the ore bodies, point very clearly to the various stages of concentration stated, with the exception of the second, which is assumed on the grounds of probability based upon the known properties of pyrite as a rock constituent. In other words, some of the pyrite is regarded as probably of sedimentary origin, and must of course have passed through all the many and complex conditions to which the Grenville sediments have been subjected, involving its circulation in ground waters, recrystallization during metamorphism under conditions of stress, and finally another recrystallization under static

conditions, whether through the intervention of magmatic or of meteoric waters or both.

In view of the nature of pyrite, it is probable that the general tendency during these operations has been toward concentration rather than dissipation, and it is possible that workable deposits might result. But, as shown above, there is reason for believing that in the final stage at least, pyrite has been added from external sources.

While, on the assumption that the four periods of concentration are well established, there is still room for much difference of opinion as to their relative importance, from what has been said above it is evident that the writer regards original sedimentation as merely of potential importance affording only disseminated pyrite which would demand great concentration to be available. Such concentration may have been effected to a considerable degree in the hypothetical second or ground-water period, was probably not greatly influenced in the third or metamorphic period, and was chiefly accomplished in the fourth or postmetamorphic period, during which, minerals formed in the third or metamorphic period were broken down and replaced by others, of which pyrite is the most important. That much of the pyrite was actually deposited in its present form and place during this period is certain, that the ore bodies are to a large degree the products of this deposition is the conclusion reached from the evidence now available.

RECENT MINERAL OCCURRENCES IN NEW YORK CITY AND VICINITY

BY H. P. WHITLOCK

PYRITE FROM KINGSBRIDGE

Some interesting pyrite crystals from this locality were described in 1893 by Prof. A. J. Moses of Columbia University.[1] These crystals which are shown in figure 1 (reproduced from figure 1 of Professor Moses' paper), average 8–15 mm in diameter, and were found in a cavity in crystalline dolomitic limestone associated with dolomite, transparent green muscovite, quartz and some minute crystals of rutile. They show only the common forms *a* (100), *o*(111), *e*(210), *n*(211) and *s*(321). Professor Moses noted a marked tendency to striation in the zone [111. 210], as well as a somewhat less pronounced striation tendency in the zone [100. 111]. This would appear to be due to incipient development of the forms (211) and (321).

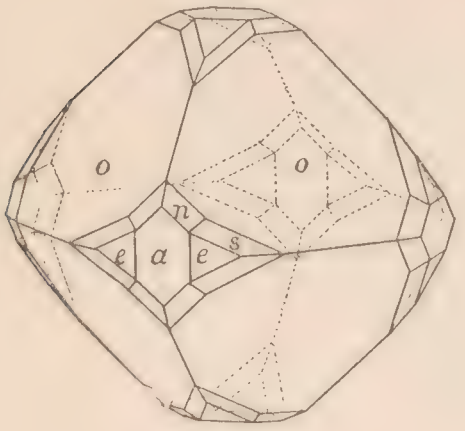


Fig. 1

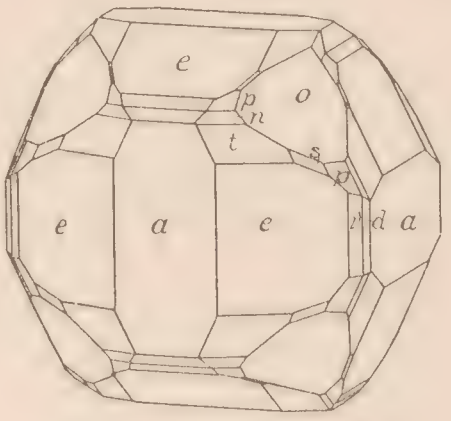


Fig. 2

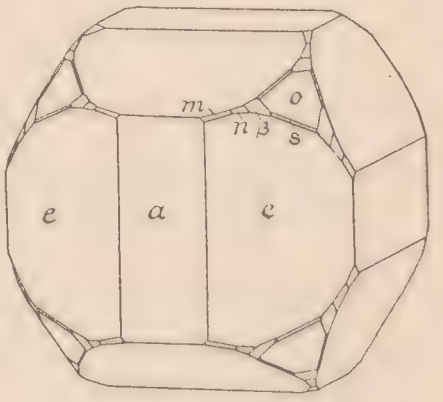


Fig. 3

The writer was recently enabled, through the courtesy of Mr James J. Manchester of New York and of the New York Mineralogical Club, to study several specimens from Kingsbridge, which proved to be of more complex crystallographic development than those described by Professor Moses.

The specimen loaned by Mr Manchester and which was collected by him during the past year consisted of a single small crystal measuring 3 mm in diameter and developed with almost diagrammatic symmetry. The faces which are sharp and brilliant gave excellent images of the signal. This crystal, which is illustrated in figure 2, shows besides the forms previously recorded from the locality the forms *d*(110), *g*(520), *υ*(650), *p*(221) and *t*(421), all of which have

[1] A. J. Moses. Am. Jour. Sci. 1893, 45,488.

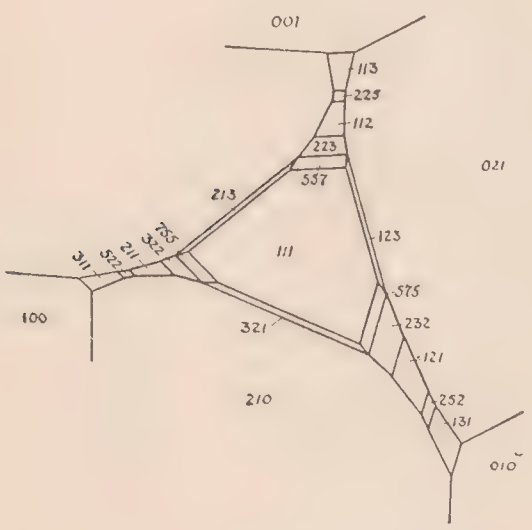
been frequently recorded for pyrite. The development of the zone [210. 001] is specially characteristic of this crystal, the forms occurring as follows: (210), (421), (211), (212), (213), (214), (001).

The forms occurring in the zone [001. 110] are: (001), (112), (111), (221), (110).

The forms were identified by means of their zonal positions as follows:

LETTER	ANGLE	NO.	MEASURED	CALCULATED
	Zone [100 . 110]			
a : g	100 : 520	2	21° 39′	21° 48′
: e	: 210	11	26 35	26 34
: o	: 650	8	39 44	39 48
	Zone [210 . 001]			
c : t	210 : 421	8	12 36½	12 36
: n	: 211	13	24 3	24 6
: p	: 212	10	41 47	41 49
: s	: 213	6	53 19	53 18
: t''	: 214	6	60 48⅓	60 48
	Zone [100 . 111]			
a : n	100 : 211	6	35 16	35 16
: p	: 122	5	15 46½	15 47½

The specimens loaned by the New York Mineralogical Club were collected several years ago by Dr George F. Kunz. The two loose crystals selected for study measured about 10 mm in diameter and were rather more distorted than the smaller crystal from the Manchester collection. These proved to be of a distinctly different type from either the Manchester crystal or those described by Moses. A crystal of this type is shown in figure 3 and an enlarged portion of the octahedral field in (figure 4.) Although for the most part the planes are well developed and brilliant, they show a greater tendency toward the formation of vicinal planes, particularly in the zone [100 . 111]. On one of the two crystals measured this tendency finds expression in the production of a vicinal prominence of the octahedral face. In addition to the forms noted by Moses the following were observed: $n(211)$, $m(311)$, $\beta(322)$, $\mathfrak{m}(522)$ and $\mathfrak{n}(755)$,



Fg. 4

the last being new to the species. The habit is more pyritohedral than either of the former types and the zone [100 . 111], although composed of small modifying planes, is rich in forms. The occurring forms were identified by their zonal positions as follows:

LETTER	ANGLE	NO.	MEASURED	CALCULATED
	Z ne [100 . 111]			
a : *m*	100 : 311	14	25° 10⅓′	25° 14½′
: m	: 522	6	29 41	29 30
: *n*	: 211	8	35 15½	35 16
: *β*	: 322	7	43 18	43 19
: n	: 755	6	45 23	45 18
: *o*	: 111	17	54 43	54 44
	Z ne [210 . 111]			
m : *e*	3̄11 : 210	3	19 19	19 17
e : *s*	210 : 321	3	17 6½	17 1½
: *o*	: 111	4	39 12	39 14

CHRYSOBERYL FROM ST NICHOLAS AVENUE

In June 1910 the writer received for identification from Mr James J. Manchester, a small specimen which proved to be chrysoberyl from a new locality on Manhattan island. The specimen in question was collected by Mr Manchester from a building excavation at the corner of St Nicholas avenue and 164th street. It consists of a single small transparent crystal of chrysoberyl embedded in Manhattan schist. The crystal, which is shown in figure 5, measures 5 mm by 8 mm, is light yellowish green in color and is so embedded that about one-half of the prismatic zone is exposed. On the partly exposed end traces of terminating planes were noted, but these were so rough and indefinite that no terminating forms could be identified. Measurements in the prismatic zone showed the presence of the following forms: *a*(100), *b*(010), *t**(11.3.0), *m*(110), *s*(120), *g**(370) and *r*(130). Of these, *t* and *g* are new to the species. Owing to the position of the matrix surrounding the crystal, only one face of each of these new forms could be observed. The planes were narrow and *t* yielded a fair, and *g* a rather poor reflection of the goniometer signal. The forms were identified from the following measurements which in every case except that of *m* corresponded to a single observation; *m* furnished two readings:

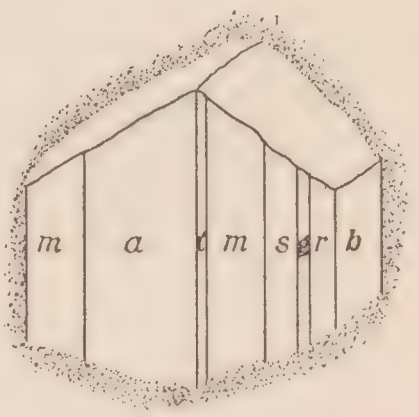


Fig. 5

LETTER	ANGLE	MEASURED		CALCULATED	
$a : t$	100 : 11.3.0	7°	21′	7°	18½′
: m	: 110	25	12	25	10½
: s	: 120	43	17	43	13½
: g	: 370	47	15	47	39½
: r	: 130	54	44	54	39½
: b	: 010	90	2	90	0

PYROXENE FROM JEROME PARK RESERVOIR

The material upon which the following note is based was collected in November 1904 by Mr J. H. Adams, from an excavation at the southern end of the Jerome Park Reservoir at Jerome avenue and 205th to 207th streets. A suite of twelve specimens from this find was placed at the writer's disposal for study, through the courtesy of the American Museum of Natural History of New York City, which institution is now the repository of the type specimens.

The minerals occur in a limestone vein in Fordham gneiss, the point of contact being marked by titanite, brownish-green actinolite in flat acicular crystals, albite and pyroxene. The last mineral which occurred on two of the specimens studied consisted of small crystals, the largest measuring 20 mm in length and 2 x 5 mm in cross section, which marked the contact phase, and minute crystals averaging 1 mm in diameter, occurring embedded in the calcite of the vein. The largest crystal of the group is shown in figures 6a and 6b. The forms observed on this crystal are: $c(001)$, $b(010)$, $a(100)$, $f(310)$, $m(110)$, $i(130)$, $e(011)$, $\mathfrak{h}(031)$*, $\sigma(\bar{1}12)$, $\mu(121)$, $R(\bar{1}32)$, $\varepsilon(\bar{1}21)$, $\upsilon(\bar{2}11)$, and $\mathfrak{l}(\bar{3}21)$*.

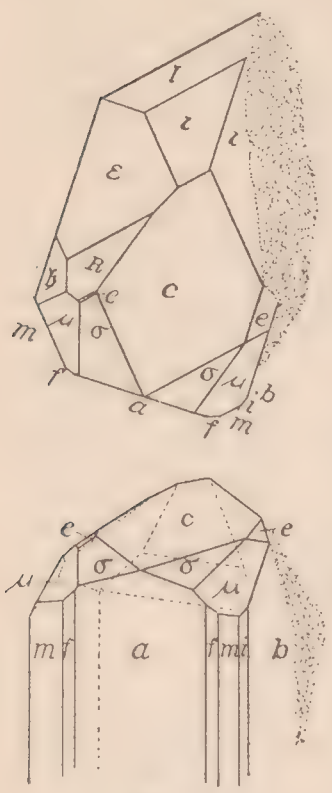


Fig. 6

The forms marked with an asterisk (*) are new to the species. In habit this crystal is characterized by the prominence and brilliancy of the planes of the pyramid $\sigma(\bar{1}12)$, a comparatively rare form for pyroxene. The new clinodome $\mathfrak{h}(031)$ was observed only once on this crystal, partly due to the fact that only one termination was exposed. The face noted, however, gave a fair image of the signal, fell well in zone with the basal and clinopinacoids and showed a close correspondence between measured and calculated angles. The new pyramid $\mathfrak{l}(\bar{3}21)$ was observed from one well-developed plane

at the intersection of the zones [110. $\bar{2}\bar{1}1$] and [100. $\bar{1}\bar{2}1$], both of which zones are well marked. The face gave fair images of the signal, fell well in the zones indicated and showed a close agreement between measured and calculated angles in these zones. The form was also found on two of the smaller crystals measured. Four of the smaller crystals referred to above were measured. These were found to be of a slightly different type as shown in figure 7, which gives three projections of one of these minute crystals. The following forms were observed: c(001), b(010), a(110), f(310), m(110), i(130), e(011), y(101), w(111), σ(112), μ(121), $R(\bar{1}32)$, $\varepsilon(\bar{1}21)$, $\sigma(\bar{2}11)$ and $\mathfrak{l}(\bar{3}21)$*.

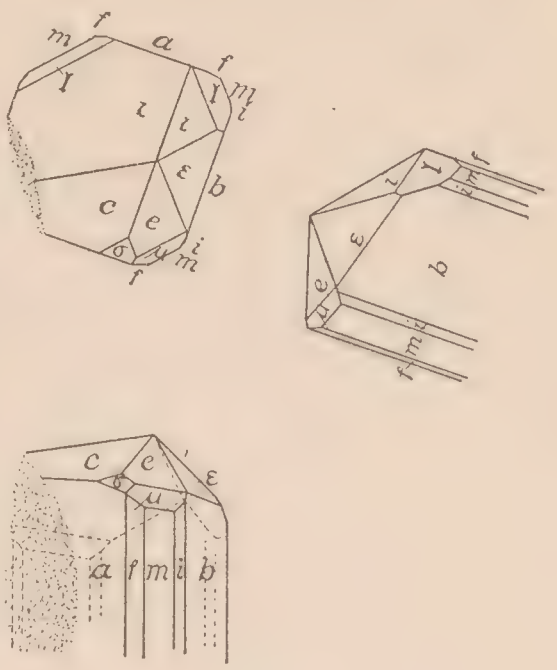


Fig. 7

The forms of this and the preceding types were identified by the following measurements:

LETTER	ANGLE	NO.	MEASURED		CALCULATED	
b : i	010 : 130	3	17°	35$\frac{1}{3}'$	17°	35′
: m	: 110	16	43	32$\frac{1}{2}$	43	33
: f	: 130	7	70	37	70	41
c : e	001 : 011	2	29	28	29	33
m : e	110 : 011	2	58	30$\frac{1}{2}$	58	35$\frac{1}{2}$
c : $\mathfrak{k}$	001 : 031	1	59	36	59	33
y : u	101 : 111	2	24	14$\frac{1}{2}$	24	15
b : u	010 : 111	2	65	43	65	45
σ : σ'	112 : 1$\bar{1}$2	1	28	45	28	48
m : σ'	110 : 1$\bar{1}$2	2	81	37$\frac{1}{2}$	81	30$\frac{1}{2}$
c : μ	001 : 121	1	47	20	47	23
a : μ	100 : 121	2	61	37	61	21$\frac{1}{2}$
m : μ	110 : $\bar{1}$21	3	35	16	35	23$\frac{1}{2}$
c : R	$\bar{0}$01 : $\bar{1}$32	1	43	50	43	57
m' : R	$\bar{1}$10 : $\bar{1}$32	2	61	21	61	25$\frac{1}{2}$
c : ε	$\bar{0}$01 : $\bar{1}$21	1	55	33	55	38
a' : ε	$\bar{1}$00 : $\bar{1}$21	2	79	37	79	51$\frac{1}{2}$
b : ε	$\bar{0}$10 : $\bar{1}$21	2	41	28$\frac{1}{2}$	41	21
m' : ε	$\bar{1}\bar{1}$0 : $\bar{1}$21	2	48	20	48	17
a' : τ	$\bar{1}$00 : $\bar{2}$11	1	54	4	54	13
b : τ	$\bar{0}$10 : $\bar{2}$11	3	65	48	65	41
m : τ	$\bar{1}\bar{1}$0 : $\bar{2}$11	3	45	19	45	28
a' : $\mathfrak{l}$	$\bar{1}$00 : $\bar{3}$21	2	47	48	47	50
b : $\mathfrak{l}$	$\bar{0}$10 : $\bar{3}$21	2	55	40	55	31
m' : $\mathfrak{l}$	$\bar{1}$10 : $\bar{3}$21	2	29	12$\frac{1}{2}$	29	19

THE MICMAC TERCENTENARY

By John M. Clarke

Recent years have given us a freshet of historic anniversaries. We are swinging through lustra laden with memories of events which subtend large angles in our destinies. We are not to be allowed to forget these, the crucibles in which we were refined. But amid these larger occasions, now and again some event of lesser note in our records strikes its anniversary, graciously salutes its own community or its beneficiaries and takes up again its little orbit.

It is one of these seemingly minor commemorations, now no longer new and so perhaps no longer news, to which, as an interested participant, I desire to refer before the event passes too far out of reach: the Micmac Tercentenary, held at Ristigouche, Province of Quebec, June 24, 1910. It has not received the public notice to which it is entitled and the occasion to remind ourselves of its significance should not be idly let pass.[1]

The date was not haphazard, nor was the place. On June 24, 1610, Membertou, grand chief of the tribe of Micmac Indians, with twenty-one of his people, was baptized into the faith by Father Jesse Fleché at Port Royal (Annapolis, Nova Scotia); on June 24, 1910, at the Capuchin mission on the Micmac reservation at Ristigouche, by the invitation of the Reverend Father Pacifique, special missioner to these Indians, chiefs, councilors and captains of the tribe, with many high dignitaries of the church, assembled to commemorate this ancient event and most momentous occurrence in the history of these people. The reverend priest who organized this successful commemoration kept in the foreground its spiritual significance. The occasion was largely a religious one but still one fraught with very real historical and ethnological significance.

The event which this interesting celebration commemorated was not one that excited in its day much comment or notice from contemporary historians. We know from a few records little else than the simple fact stated above. It may be found in Lescarbot's

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[1] The writer attended this interesting fête as a delegate from the Education Department and the New York State Historical Association.

Relation Dernière and in a letter addressed by an eye witness named Bertrand to the Sieur de la Tronchaie.[1]

We need not take this occasion to review Parkman's rather austere and injudicial portrayal of Poutrincourt's zealous efforts to bring the aged Chief Membertou and his tribe into the church. The deed was done in fervor; whether it was done to anticipate the Jesuits in the same field, matters little now. The baptism at Port Royal stands as the achievement of a conviction supported by resolution, the combination that has always done things that are worth while. The old chief, having given his adherence to the new religion, instilled his faith into all his tribe, perhaps whether they liked it or not, until all the Micmacs under his control had surrendered fully to the new religion. And thus at Annapolis began the spiritual regeneration of the tribe till, under the labors of the "Black-robes" and the "Bare-feet" alike, it extended throughout the entire domain of the Micmacs in Acadia and Gaspesia. However historians, in the conventual repose of their libraries, may construe the initial effort, the seed was planted and the occasion of June 1910 showed something of the harvest.

There was a far deeper meaning to this event — one which it was not the purpose of the tercentenary to commemorate and was obviously omitted, but it has stamped an elemental influence on the history of this western continent. The Micmacs were the first of the American Indians to surrender to the white man's religion.

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[1] The latter is quoted by R. F. Pacifique in a souvenir brochure issued in advance of the tercentennial: "Une Tribu privilegiée" — an illuminating and erudite history of the tribe and a sympathetic analysis of the Micmac psychology. This pamphlet is itself an important historical document, for its author is, of all men, he who doubtless knows the Micmac people best, has sojourned with them most, has received their confidences, soothed their anxieties, advised them in their spiritual and secular interests oftenest. For them he has printed prayer books, hymnaries and catechisms in their own language and today issues a monthly journal, "Le Messager Micmac," in their tongue. Thus incidentally to his spiritual labors he has rendered a great service to philology and linguistics in helping to conserve this Souriquois language. It is surely upon this learned and devout Franciscan that the mantle of his confrère, LeClercq, the intrepid missioner to the "Savages" in the Gaspé peninsula in the 1600's, when the country was wild and they were wilder, has fallen. He has succeeded to the labors of the devoted Biard and Maillard. To the publication we have referred and to his later "Souvenir" of the tercentenary, the writer (or indeed any writer on this theme) must perforce be attentive and from them a constant borrower.

That meant a bond offensive and defensive with the Frenchman who had instilled the new faith. If by the chance of adventure, of geography or of discovery these Indians had been Iroquois instead of the bitterest enemies of that great Confederacy, the whole course of American history would have run in a very different channel. But with the conversion of Membertou and his tribe to the faith of the Frenchman, the die was cast. Mutual and historic enmities alined themselves. The Micmacs first (the Souriquois, as the early French called them), and then in the logical sequence of history the entire Algonquin stock of which they formed a branch, became the allies of the one culture; their enemies, the Iroquois, by very grace of this fact, became the enemies of that culture, and no effort of colonization, of treaty, of conversion (though none was spared) ever could turn the scales the other way. The great Confederacy of the Six Nations, holding the apex of the critical triangle in New York at which converged the St Lawrence pathway of the French and the Hudson-Mohawk pathway of the English, held the balance of power between the two. If we analyze our history down to its roots it is perfectly right to look back on the conversion of Membertou, his squaw, his children, his children's children and his tribe as the first step toward the ultimate supremacy of the English culture in America.

The student of Indian ethnology may look upon the Micmacs as only a little tribe, of small moment in the sum of aboriginal history, but, spread out along the northeastern shores of the Atlantic, they were the first of all American Indians to come in close contact with the whites, and today they are the only Indian tribe in all America that has held its own in numbers; its members are as many as when the Europeans first saw them. In this statement there are, of course, only the estimates of the early missioners, LeClerq and Biard, to guide us, but the fact seems well established. Father LeClercq, laboring in Gaspé, the northern reaches of their hunting grounds where their number was always few, thought in 1680 that his "Gaspesians" numbered no more than 500, but Biard at an earlier date (1611) and nearer the center of their settlements in Acadia, estimated them at 3000 to 3500. In 1871 Hannay in his history of Acadia, placed the number at "nearly 3000" and adds "it is doubtful if their numbers were ever much greater." Dr Dionne, the distinguished historian of Quebec, says that in 1891 the Micmacs numbered 4108; Father Pacifique in 1902 made a personal enumeration of the tribe and placed the number at 3850

in Canada and 200 in Newfoundland. Today according to Father Pacifique and the last official census there are 4319 members of the tribe, of whom only 230 live in Newfoundland and about 15 in the United States.

It is thus very evident that the tribe has been one of extraordinary vitality and has perpetuated itself and even multiplied in the face of much the same conditions which brought about the depopulation of every other aboriginal people of this hemisphere. Some ethnologist with the proper psychological equipment might well seek out the causes of this phenomenon. Evidently somewhere in their composition or their environment, by nature or by grace, there has lain a resistant virtue which other tribes have missed, though both by nature and grace, their lands have not greatly invited the white man's lust.

It is not that these Indians have increased by excessive mixture with the whites. This tendency to intermarriage has never been general among the people nor has it essentially modified their physical type. On the other hand, one can not fail of being impressed with the perfection of the physiognomy and the sturdiness of the physique in all the better men of the tribe. Father Pacifique says:

"It is true there have been many crosses, legitimate and illegitimate, but in a few generations the type will be fully restored. I have observed that the last children of mixed families are less white than the first born. Moreover their attachment to their beautiful language is a guaranty of cohesion and permanence."

The learned father has here noted a Mendelian factor of ultimate force in insuring a stable or aboriginal type from variation, and which is quite sure, in the mixture of races, eventually to dominate the secondary or derived type represented in this case by the whites.

The Micmacs, too, hold to their original soil. Too many of our aborigines have been shifted about, the shuttlecock of the white man's designs, and find themselves today far away from their old hunting grounds. The Micmac country was the extreme orient of the Algonquins, and in the historic confederacy of this Algic stock which once covered half the continent, they were the "youngest brother," their land *Migmagig,* the "country of friendship." The "elder brother" was the Abenaki to the south and west, while the "father tribe" was the Ottawa, their land the "land of their origin."

The tribe is scattered as in the days of Cartier, and spreads through the region over which Nicolas Denys held patent as lieutenant governor in 1658 from "the Cap de Campseaux as far as the Cap des Roziers." There are fifty-six small settlements or reservations scattered all the way from the Gaspé peninsula to Cape Breton, the largest of all being at Ristigouche, the seat of the Capuchin monastery and church of St Ann and the metropolis of the tribe, where they number 506. Their segregation into widely scattered but numerous settlements is unusual in the present disposition of the Indian tribes and might seem to expose them, by the very fact of freer contact with the whites, to variation and change. They speak the French in French communities and the English in English, but for business purposes only. Among themselves their own language alone is spoken and without variations, no matter how wide apart their homes may be. "It is certain that the race is not disappearing either by extinction or by absorption" (F. P.). This fact is all the more noteworthy because these Indians have been in no wise exempt from the curse of alcohol,[1] tuberculosis and syphilis. These evils have played havoc here, as they have and do today elsewhere among the aborigines. It may be that their general poverty (for there is a total absence among them of the occasional prosperity one sees among the other tribes) and their ignorance of hygienic living will eventually make inroads on their vitality which the life out of doors may not be able to combat — and here lies at the hand of their legal guardians and of their white neighbors an immediate duty.

I could not venture to write even in summary the part the Micmac tribe has played in history. It is knit close to the story of early French settlement of Acadia. The enmities of the French were ever its enmities, and this hostility to the English was not based on religious grounds alone. The difference in the attitude of the French and the English toward the Indians is of common knowledge. By the French they were never regarded as subjects of the French king so much as his wards and so by the French clergy they were ever treated not only with gentleness but with

[1] Long ago Denys painted in vivid colors the fearful effects of the Frenchman's liquor on these savages. For this, in those days of the 1600's, they spent their very lives; all the spoils of the winter's hunt were exchanged for liquor and the summer was one long debauch till the fishermen sailed away from the coast. All this has passed and yet today with them, as with all the aborigines, firewater makes the Indian into a savage again and brings out to the surface all that religion has helped to bury.

prudence. The French missioners found them in their simple-minded naturalness and though their spiritual labors were slow of fruitage,[1] the hardship was intensely magnified by the incursions of the English. One who would realize this may well read the account given by LeClercq of the burning of his churches and missions by the "Bastonnais" (Phips). So through the early history of Acadia they were friendly neighbors to the French, and with the English conquest they submitted, not without some hesitation, to the changed régime, and made their allegiance to the new sovereign. When the American war came on efforts were made through the King of France to induce them to revolt against the English, but the advances of Count d'Estaing and Commander Preble were sternly rejected in forcible terms.[2]

Today they are loyal and the most ancient of all Canadians.

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[1] LeClercq in Gaspé more than once speaks of the discouragements of his task and finally begged of his superior to be relieved of further efforts to convert the Gaspesians.

[2] Chief Jerome of Ristigouche exhibited on the occasion of the tercentenary a copy of a "Declaration au nom du roi, a tous les anciens Francais de l'Amerique Septentrionale" printed on board the *Languedoc* in Boston harbor October 18, 1778. At the bottom of the first page is written by hand: "A mon cher Frère Joseph Claude et autres sauvages Mickmacks. De la part de Monsieur le Comte d'Estaing, Vice-Amiral de France, Holker, agent general de la marine et consul de la Nation francaise."

With the rest of the settlers of the St Lawrence coasts, the Micmacs had learned to dread the repeated invasions throughout the old régime, which took their start from Boston. The "Bastonnais" were well hated and not a little feared, so that in time the term became of common application to all the English. I think the term is not quite extinct — at any rate I have heard a French fisherman call a rather disagreeable American tourist in Gaspé a *Bastonnais,* with all the old feeling that the epithet must once have carried. Even yet, to the Micmac, the States is the country of the *Bastonnais,* and on his map of the world the whole area of the United States is called "Poston." Thus the evil that men do lives after them and Boston is by merit raised to this eminence.

The ancient traditionary fears of the gentle-minded Micmac had a curious illustration on the occasion of the tercentenary. While the Indians were gathered in the church for the opening ceremony on the morning of the first of the three days, some mischievous miscreant circulated the story that their old enemies the Iroquois, having heard of this assemblage, were lying in the woods outside ready to take advantage of their helpless state and fall upon them. After the mass and the sermon by the missionary, there appeared a growing restiveness among some of the Indians, whispers and awed looks spread through the pews, and these were not wholly dispelled till the wise and patriarchal Grand Chief had assured his people that such a story could only be the invention of the father of lies.

The interesting commemoration gives rise, in my mind, to reflections on a well-worn and ever present theme — the attitude of the white master toward the Indian. Perhaps as a titular official of the Iroquois League the writer may have had opportunity to acquire a right to this expression: There is one perfectly evident inference from the apparent motives and the actual dealings of the French and English cultures with their red allies, whether expressed in provincial, state or federal attitude; the French would ever let the red man be a red man; the English would make the red man into a white man. That is the situation succinctly stated. It would be just to go further and put the statement thus: that Canada would let the red man develop along lines of least resistance, while America has ever insisted and is still insisting on at once turning the red man white. The problem has worked its way along further in the older east than in the newer west.

I fancy we may not ascribe to the founders of our governments on either side the line any profound recognition of natural law, but it has certainly so happened that French Canada and French influences in Canada have been content to grant the fundamental difference in culture and to leave the Indian to come up slowly from his barbaric state under a spiritual rather than a civic impetus. It is thus the natural law works — slowly, if effectively. A great abyss in nature, profoundly divergent lines of culture meeting at their start but standing wide apart at the extremes, can not be jumped by legislative enactment. Lines of racial development, one following far behind the other, can not be brought together by the process of legislative stretching. The law that says red is white has either a fool or a knave for its author. Just as little can great monetary foundations designed to effect immediate alterations in the slow but orderly procedure of natural law — such as the development of language or the establishment of universal peace — escape the conditions which that law imposes. The supremacy of a law which lies above the statute and the common law is a fact which statute makers and statesmen have been slow to learn; experience is full witness to this. The English attitude toward the American Indian has never once suggested the concession that the Indian has just as much right on this earth as he, and has played just as significant a part in human progress. To the English colonists and the ideas they have left alive, the red man is a potential citizen as soon as he can be forced to measure up to

certain more or less artificial conditions of education and deportment.[1]

French Canada assumed from the outset that the gap between the Indian and the Frenchman was the chasm between a primitive and advanced culture which only the slow process of time could bridge — it seemed to recall the ages which had been necessary for the Frenchman himself to come up from a like aboriginal condition. At any rate what the Catholic pioneers of New France saw in the Indian and what their successors still see is that the Indian has a soul to save. To bring him to adjust his natural religion to the more adequate conceptions of Catholicism was the purpose of the majestic and sublime sacrifices which so brilliantly illumine the pages of the old régime. No judicial mind can contemplate the results of Catholic and Protestant missionary endeavor among the American Indians and avoid the conclusion that the Catholic Indians have on the whole preserved their physical aboriginal type in greater perfection, have kept much of their tribal culture, possess a deeper religious conviction. Among the Protestant Indians there are many instances of individual attainment of noteworthy excellence in education, public usefulness and personal uprightness, but it is perfectly evident that the term Protestant as applied in some of the Indian tribes does not mean Christianized, so much as it implies an avowal and allegiance to a given form of religious worship, and in many cases, little else. My own personal observation is restricted to neither class, and I believe there is good reason for saying that, broadly, in matters of faith the Catholic Indian is a Catholic while the Protestant Indian is an Indian. It is an important fact in its historical bearings that the tribes which have been subjected to the most direct and persistent Protestant effort have never fully surrendered their natural religion. Indeed among the Iroquois of New York and Canada there are two very distinct interests in the League represented by the "Christians" and the "pagans."[2] So far as my knowledge goes, this is not at all the condition among tribes acknowledging allegiance to the Catholic church.

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[1] In the condition of the Six Nations Indians in Canada and New York, there is a contrast, either creditable to the one government or discreditable to the other. Canada has let its Iroquois work out their own salvation and these Indians today are well educated, energetic, aggressive and fairly prosperous. In New York the reports of 1910 show that more than one-third (35.5 per cent) are illiterate.

[2] The Canadian Oneidas have now gone back to paganism after years of Protestant missionary labors.

We have already said that the conversion of the Micmacs was an elemental and influential factor in the historic conflict of English and French cultures on this continent. We are not likely to exaggerate its importance, whichever way the tides of events turned. It would be unfair and historically inaccurate to say that the influence of the Grand Chief Membertou on the Micmac tribe, allied with the efforts of the devoted French missioners, finds its counterpoise in the single personal hold of Sir William Johnson who by force of his own personality kept back the Iroquois from alliance with the French. The two opposed facts are of different magnitude and unlike in quality, but similar in their antagonistic effect. Let us give to this historic event of 1610 all its true meaning in the century-long struggle between the French and English cultures. That struggle took its final direction in the contest for this continent, and the spectacular victories of Amherst and Hardy and Wolfe were made possible only by the strong hand of His British Majesty's Indian Agent, which held back the Iroquois from the French interests.

THE MANHATTAN INDIANS

BY ALANSON SKINNER

INTRODUCTORY

Some time before the advent of the Dutch at New Amsterdam, a branch of the Lenni Lenapé or Delaware Indians split off from the parent stock, which had its abode south and west of the Hudson and moved eastward and northward forming the Mahikan tribe. They occupied Manhattan island and the east bank of the Hudson as far north as the southern boundary of the Mohawk Iroquois. In time they became subdivided into several subtribes and bands, the chief of which, known as the Wappinger Confederacy, was composed of the Wappinger, Kitchawanck, Sintsinck, Siwanoy, Weckquaesgeck and Reckgawawanck. Of these people the two tribes last mentioned were found by the Dutch inhabiting Manhattan island. At that time the Weckquaesgecks held the upper part of the island above a line drawn from the Rechewa's creek (later Harlem creek) to the ravine at what is now Manhattanville, and the Reckgawawanck occupied the lower part of the island. Both of these tribes also held territories on the mainland where their principal abodes were situated. The name Manhattan referred to the portions of both tribes dwelling on the island and it is said to mean "Islanders." Although the modern Delawares insist on translating "Manhattanink" as "The Place Where They Were All Intoxicated," basing the name on the traditions of their first meeting with the whites and their introduction to spirituous liquors.

All the old records claim that Manhattan island was used not as a permanent abode but as a hunting and camping ground, assertions which, however true at the time of the Dutch occupation, do not seem entirely to hold good of the prehistoric period.

Our first records of the Manhattan Indians or their kindred date from Verrazano in 1524, and we have little further information in regard to them until 1609 when Hudson entered New York harbor. The first account of the Indians of the neighborhood of New Amsterdam is also by Verrazano[1] who said that they did not differ much from the natives whom he had met elsewhere along the coast and that they were of good proportions, medium height, deep chested and strong armed. He met among others "two kings more

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[1] Collection of the New York Historical Society, 2d series, 1:45.

beautiful in form and stature than can possibly be described; one was about forty years old, the other about twenty-four." They were dressed in the following manner:

"The oldest had a deer's skin around his body, artificially wrought in damask figures, his head was without covering, his hair was tied back in various knots, around his neck he wore a large chain ornamented with many stones of various colors. The young man was similar in his general appearance." In stature, he relates "they exceed us," their complexion swarthy, faces sharp, hair black and long, eyes black and sharp and expression pleasant and mild. The women were "of the same form and beauty, very graceful, of fine countenance, and pleasing appearance in manners and modesty." Clothes they had none "except a deer skin ornamented like those of the men." Others wore "very rich lynx skins upon their arms, and various ornaments upon their heads, composed of braids of hair which hung down upon their breasts on each side. Older married men and women "wore many ornaments in their ears, hanging down in the oriental manner." They were generous, giving away whatever they had. The women usually stayed in the canoes when they came to the ship.

Our next data in regard to the personal appearance of the natives of old New Amsterdam is in Hudson's mate's journal written in 1609: "The people of the country [perhaps Staten island] came aboard of us, seeming very glad of our coming, and brought greene tobacco, and gave us of it for knives and beads. They goe in deere skins loose, well dressed. They have yellow copper. They desire cloathes, and are very civill. They have great store of maize or Indian wheat, whereof they make good bread. . . . Some of the people were in mantles of feathers, and some in skinnes of divers sorts of good furres. Some women also came to us with hempe. They did weare about their neckes things of red copper. At night, they went on land againe, so wee rode very quiet, but durst not trust them."

The next day after Hudson dropped anchor in the Lower bay, he sent out the ship's boat with a crew of five men through the Narrows to the Upper bay to make some observations. As they returned, they were met by a score or more of warriors in two canoes and were speedily drawn into a quarrel with them. One sailor, an Englishman named John Colman, was killed by an arrow shot through his neck and two others were hurt. Colman was afterwards buried at a point usually identified as Sandy Hook, which for many

years bore his name. Some local historians, in writing concerning Staten island, have placed the scene of Colman's death at the locality now known as the Cove, in West New Brighton, Staten island, but there is little evidence to confirm this.

At a later date Van der Donck stated the young warriors wore "a band about their heads, manufactured and braided, of scarlet deer hair, interwoven with soft shiny red hair," perhaps very much like the deer's hair head dresses worn today by the Sauk and Fox, Sioux and other modern tribes, "with this head dress they appear like the delineations and paintings of the Catholic saints. . . . When a young Indian is dressed this way he would not say *plum* for a bushel of plums. But this decoration is seldom worn unless they have a young woman in view."

"The women wear a cloth around their bodies, fastened by a girdle, which extends below their knees, and is as much as an undercoat; they wear a dressed deer skin coat, girt around the waist. The lower body of this skirt, they ornament with great art, and nestle the same with strips which are tastefully decorated with wampum. The wampum with which one of these skirts is ornamented is frequently worth from one to three hundred guilders. They bind their hair behind in a club about a hand long, in the form of a beaver's tail, over which they draw a square cap, which is frequently ornamented with wampum. When they desire to be fine they draw a head band around the forehead which is also ornamented with wampum, etc. This band confines the hair smooth, and is fastened behind over the club, in a beau's knot. Their head dress forms a handsome and lively appearance. Around their necks they wear various ornaments, which are also decorated with wampum. Those they esteem as highly as our ladies do their pearl necklaces. They also wear hand bands or bracelets curiously wrought, and interwoven with wampum. Their breasts appear about half covered with an elegantly wrought dress. They wear beautiful girdles, ornamented with their favorite wampum, and costly ornaments in their ears. Here and there, they lay upon their faces black spots of paint. Elk hide moccasins they wore before the Dutch came, and they too were most richly ornamented."

Van der Donck states that chiefs or men of wealth and importance had a plurality of wives, but that this was not the rule. Chastity seems to have been considered a virtue, and was much more common in this immediate vicinity than among the Algonkin of the north.

Enough has been here stated to give a general idea of the personal appearance of the Indians about Fort Amsterdam at their first meet-

ing with the white men and at a later date. Their ethnology has been more fully described elsewhere.[1]

As Hudson journeyed northward up the river which now bears his name, he had many experiences with the natives, some friendly, others warlike. On the return trip he tried to kidnap two young warriors from an Indian village, but both of his intended victims escaped and jeered at their would-be kidnaper, and one of them shortly returned at the head of a band of his friends in a swarm of canoes. As they were not allowed to board the "Half Moon" which was well under way, they fell behind and sent a storm of arrows in her direction. Six musket shots from the ship killed two or three of the warriors, and discouraged the rest, who retreated to a point of land whence they returned to the attack, but a cannon shot killing two of them drove the rest to the forest. Still undaunted, another war canoe set out, manned by nine or ten men, which was promptly sunk by a cannon shot, and a volley from the muskets of the sailors destroyed three or four more, and the unequal battle being terminated in triumph, the victors set their sails for home. This entire scene is supposed to have taken place at Inwood and about the mouth of Spuyten Duyvil creek. At the former place especially, traces of Indian settlements are still to be found. Thus ended the first chapter of the dealings of the Manhattan with the whites, a fitting prelude to the scenes soon to be enacted.

During the next four years white men were more frequently seen on Manhattan island and by 1613 the Dutch were firmly established at Fort Amsterdam. As they progressed up the Hudson river the new-comers soon learned that all the Algonkins in the vicinity were in deadly terror of the Five Nations of the Iroquois, especially the most eastern tribe, the Kanienga, or as the River Indians termed them, "Maquas or Bears, (a name probably suggested by one of the most powerful of their three clans, and from which our word Mohawk is derived).

These ferocious warriors had contracted through a deadly hatred of the French the mistaken policy of Champlain at whose hands they had suffered defeat some nine years before near what is now Ticonderoga, and they hailed the advent of the Dutch with delight, perceiving at once that here lay their opportunity to obtain the firearms they needed to triumph over their neighbors and enable them to be revenged upon the French.

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[1] Skinner. The Lenape Indians of Staten Island. Anthropological Papers, v. III, p. 3.

The Dutch, on the other hand, soon recognized that the Five Nations would be a powerful ally in case war broke out among the Indians about Fort Amsterdam, and so in 1618, in the Tawasentha valley, the famous offensive and defensive alliance between the Dutch and the Iroquois was formed, an alliance kept up at a later date by the English, and which resulted in the downfall of France in the New World, through the untiring agency of this resolute group of American savages, but it was an evil day for the Manhattan when the treaty was made with their most powerful and deadly enemies.

In 1626 the entire island of Manhattan, about 22,000 acres in all, was purchased by Peter Minuet, then governor, for 60 guilders worth of trinkets. Twenty-four dollars is the amount which is usually rendered as the equivalent of this sum, but as the value of gold was then five times greater than at present, it amounted to some one hundred and twenty dollars, a liberal sum compared with many Indian purchases of those days. However, according to the old accounts, the Indians considered the island as being divided into two parts, the upper half above the Harlem creek remaining unsold.

From the first the dealings of the Manhattan and the Dutch seem to have been fraught with treachery and violence on both sides. While Minuet himself appears to have been open minded and just, his subjects were not all of the same calibre, and the seeds of war were sown daily in the bosoms of the Indians.

In 1626, the same year that the purchase of Manhattan island took place, a Weckquaesgeck Indian from the vicinity of Yonkers, accompanied by his nephew, who was only a small boy was bearing his furs to the fort to trade when they were waylaid and robbed by some servants of Minuet himself. The Weckquaesgeck was murdered before the eyes of the child, who escaped bearing with him a memory of violence which, according to Indian ideas, could only be erased by blood.

Continual aggressions by the Dutch caused endless friction with the savages. Lands were fraudulently acquired, cattle belonging to the whites trespassed on the Indians' corn fields unchecked, and when the natives took the law in their own hands and slew them, reprisals were in order. So affairs went from bad to worse, intolerance and discord growing on either side.

During the misadministration of Governor Kieft, that worthy decided to tax the Indians to compensate for what he considered their constant misdemeanors and to establish a firm hold over them, and he went so far as to send an armed sloop to the Tappan to

collect this tribute in corn and wampum, but the Indians scornfully refused to pay and made sarcastic speeches about the Governor.

The following year, 1640, some of the Dutch West India Company's servants stole some hogs from De Vries's plantation on Staten island, and Kieft, wishing for a pretext to rid himself of a few of his Indian neighbors, blamed it on the Raritans and sent his secretary, Van Tienhoven, in charge of twenty men to punish the Indians for their alleged theft. The party went to a spot located, according to De Vries, somewhere behind Staten island, probably on the New Jersey shore. When the destination was reached the men became insubordinate and decided, against the earnest appeal of the secretary, to murder every Indian they could. At last Van Tienhoven left them in despair and proceeding but a short distance they came to the Indian settlement where wigwams and crops were burned and a number of Indians killed, including the brother of the chief, who was atrociously murdered after he had been made prisoner by one Govert Lockermans (De Vries in his Journal says this man was not killed but outrageously maltreated). They then withdrew, leaving one of their number dead upon the field of victory. As a result the plantation of David Pietersz De Vries on Staten island, was promptly attacked by the angry natives, four of his planters were killed and his tobacco and dwelling houses destroyed. After a time this trouble blew over but more friction was at hand.

Claes Smit, a Dutchman, was approached one day by a young warrior who offered him some beaver skins to trade. Smit went to comply when the Indian tomahawked him, plundered the house and escaped. It was the young Weckquaesgeck, who, according to Indian ideas, had avenged the murder of his uncle so long before. Kieft demanded the murderer, but was refused by his tribesmen. Kieft then called a general council and laid the matter before it, suggesting that in case the murderer were not forthcoming, his whole village might be destroyed. The council referred the matter to the "twelve select men," who wisely suggested that quiet preparations for hostilities might be carried on in secret, and that in the meanwhile a sloop be sent to the Weckquaesgecks to demand the murderer, "once, twice, yea for a third time" in a friendly manner.

About this time Miantonimo, the chieftain of "Sloops," or as it is now called, Narragansett bay, visited the Manhattan and other local Indians in order to get their alliance in a controversy pending with the Mohegan. This threw the Dutch into confusion for a time, as he was suspected and accused of stirring the Indians up against them, but at length the scare blew over. Immediately following

this a Hackensack Indian was made intoxicated and robbed by the Dutch and, in spite of the friendly efforts of De Vries, who met and tried to quiet him, he was so enraged that he murdered a settler in Myndert Mynderssen Van der Horst's colony near Achter Cul or Newark Bay.

This was an unfortunate happening as neither the Hackensack nor Tappan had been embroiled with the Dutch before. The Indians were not in sympathy with the act and at once offered the director, Kieft, through De Vries, two hundred fathoms of wampum to be given to the family of the victim to compensate the crime, as was their custom. This Kieft refused and at length the chiefs visited the fort at the intercession of DeVries, whom they trusted, and who became responsible for their return, and there they repeated their offer. Kieft demanded the murderer and refused the wampum. The Indians could not produce the culprit as he had fled to the Tankitekes or Haverstraws, and moreover he was a chief's son and could not be surrendered. They once more renewed their offer of payment which was refused and they returned uneasily, while Kieft bided his time which shortly arrived.

In February 1643 a band of Mahican armed with muskets came from the upper Hudson below Albany and made a raid on the tribes about Fort Amsterdam, driving them in terror to the Dutch for protection after killing seventeen of their number and taking some of their women and children prisoners. The Dutch sheltered and fed the fugitives and after two weeks they returned to their homes, but a second alarm drove them again to the Fort and to Vriesendael (De Vries settlement). De Vries helped them as much as he was able and begged Kieft for soldiers to assist them, but these were refused. The Indians then congregated at Pavonia among the Hackensack "full a thousand strong," and others at Richtauck (Corlear's hook on East river, not far from the site of Grand Street ferry) where they occupied some cabins erected by the Reckawancks.

The majority of the Dutch, under the lead of De Vries, believed that this was their opportunity to treat the Indians with kindness and so win them over. Kieft, however, in his usual hot-headed and blood-thirsty manner, saw otherwise and decided to do a deed which has rarely been equalled for cruelty and treachery. At midnight Sergeant Rodolf was sent among the sleeping and unsuspecting Indians at Pavonia where he murdered eighty of them in the most brutal manner, and soldiers under Maryn Adriansen massacred forty more at Corlear's Hook. De Vries has left us a manuscript in which he describes the entire outrage, to which he was an eye witness, in scathing terms.

When the Indians learned it was not the Mahican (or as they had supposed, the Mohawk) but the director that they had to thank for their inhospitable entertainment, eleven tribes took the war path. Farmers and settlers outside the immediate walls of the fort were killed on every hand, and the Dutch were terrified.

Even Vriesendael was attacked and partially destroyed. De Vries and his people were fortunately able to escape to the fortified manor house where they awaited the assault, when an Indian whom De Vries had managed to save from the massacre appeared and told the assembled warriors that De Vries was "a good chief" persuaded them to desist. This they did with protestations of regret that they had slain his cattle and burned the houses, and though they wished very much to have the copper kettle in the little brewery to make arrowpoints, they left it where it was and withdrew regretting that they had injured their friend.

The Dutch fled to the fort for protection and were loud in their complaints against Kieft, who met them defiantly at first and blamed the calamity on Adriansen, one of his councillors, who promptly sought to vindicate his honor by slaying the governor, an attempt in which he unhappily failed. At last, according to the old documents, terror reduced Kieft and his people to begging from God the mercy which they had not granted the Indians that night at Corlears Hook and Pavonia.

Toward spring the savage warriors began to relent, the Long Island Indians sending three men from the wigwams of their chief Penhawitz to open negotiations, from whence De Vries and a man named Albertson, the only settlers who were not afraid to go, accompanied them back to their village. Setting out on the 4th of March they arrived at Rechquaackie or Rockaway where they found Penhawitz and nearly three hundred warriors at a village of thirty lodges. "Next day," says De Vries, "we were awakened and led by one of the Indians upwards of 400 paces from the route where we found sixteen chiefs from Long Island who placed themselves in a circle around us. One of them had a bundle of small sticks. He was the best speaker and commenced his speech. He related that when we first arrived on their shores, we were sometimes in want of food, they gave us their beans and corn, and let us eat oysters and fish, and now for recompense we murdered their people. He here laid down one little stick, this was one point of accusation. The men whom in your first trips you left here to barter your goods till your return, these men have been treated by us as we would have done by our eye-balls. We gave them our daughters for

wives, by whom they had children. There are now several Indians, who came from the blood of the Swannekins (Dutch) and that of the Indians; and these, their own blood, were now murdered in such villainous manner. He laid down another stick." [1]

De Vries invited the chiefs to the fort and eighteen of them went with him in a large canoe to visit Kieft. They received presents and assurances, and at length on the 25th of March peace was arranged. Through the efforts of the Long Island Indians, peace was also concluded on the 22d of April with the Hackensack, Tappan, Reckawawanc, Kitchawanc and Sint-sinck. The presents given to the Indians were meager, however, and the Hackensack especially complained of their insufficiency. During the summer their Sachem warned De Vries that his young men were preparing for the war path, but Kieft gave the chief an insolent message and refused to pacify him with further gifts.

When difficulties again began in New England, in 1643, the Indians took up the hatchet as had been predicted. The trouble was begun by the Wappinger, who seized a boat coming from Fort Orange, killing two men and capturing four hundred beaver skins. Kieft called a committee of eight to consult on this and other outrages, but before a decision was reached, the Weckquaesgeck destroyed Anne Hutchinson's settlement at Pelham Bay and killed that noted woman and captured her youngest daughter, a child of eight years, who was given up to the Dutch at the fort four years later, when she had forgotten her native tongue.

Throgmorton's settlement at Throg's Neck was next destroyed, but here the inhabitants escaped in their boats. Pavonia was burned under the guns of two warships and a privateer, and outside the very fort itself, Manhattan island lay in embers and ashes. "They rove continually around day and night on the island of Manhattan, slaying our folks not a thousand paces from the fort." (Col. Hist. 1:216, 211.) At this juncture, De Vries was obliged to return to Holland, and left calling the vengeance of God upon Kieft's head as the author of so much misery and bloodshed.

Kieft now begged aid from New England, offering twenty-five thousand guilders for one hundred and fifty men, and even offered to mortgage New Netherlands to the English for aid; at the same time beseeching Holland for relief.

He received, however, only a few English volunteers under the command of Captain John Underhill, who was a combination of

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[1] De Vries. New York Historical Society Collections, 2d series, 1: 231.

bravery, piety and fiendish cruelty hard to equal. Of the conduct of this genial gentleman in the New England wars, Trumbull has said, "He could justify putting the weak and defenceless to death, for says he, 'The Scripture declareth women and children must perish with their parents . . . we had sufficient light from the word of God for our proceedings.'"

Two companies were soon organized, one of sixty-five men and the other of seventy-five men. The second company was composed of forty burghers under Captain Pietersen and thirty-five English under Lieutenant Baxter, Councillor La Montagne acting as general. This band made a raid upon the Staten Island Indians, but succeeded only in obtaining some corn which had been abandoned. Returning to the fort they were reinforced by one hundred twenty men and invaded the Weckquaesgeck country. They landed at Greenwich, marched all night and found nothing. As they retreated through Stamford they met some English who told them there were Indians nearby. Scouts located an Indian village and twenty-five soldiers sent there killed a number and took some prisoners. Guided by a captive they located three empty Weckquaesgeck "castles" and burned them, after which they returned.

Meanwhile Underhill landed on Long Island and set out to attack the Canarsies under Penhawitz. After landing, Captain Pieter Cock and General La Montagne set out with eighty men to destroy a large settlement at Maspeth and Underhill while fourteen men were sent to a small village or camp at Hempstead. Both parties were successful, killing one hundred twenty Indians, only one of the whites being killed and three wounded.

The English minister Fordham had seven Indians accused of pig stealing locked in his cellar. Three of these Underhill himself killed, two were towed in the water until they were dead, and two were taken to Fort Amsterdam where they were turned over to the soldiers to amuse themselves with.

"The first of these savages having received a frightful wound, desired them to permit him to dance what is called the kinte-kaye, a religious use observed among them before death; he received, however, so many wounds that he dropped down dead. The soldiers then cut strips from the other's body, beginning at the calves up the back, over the shoulders and down to the knee. While this was going forward Director Kieft and his councillor, Jan de la Montagne, a Frenchman, stood laughing heartily at the fun and rubbing his right arm, so much delight he took in such scenes. He then ordered him to be taken out of the fort, and the soldiers bringing him to the

beaver's path (he dancing the kinte-kaye all the time) threw him down, cut off his partes genitales, thrust them into his mouth while still alive, and at last, placing him on a mill stone, cut off his head. . . . . There stood at the same time some twenty-four or twenty-five female savages, who had been taken prisoners and when they saw this bloody spectacle, they held up their arms, struck their mouths, and in their language exclaimed, 'For shame! for shame! such unheard of cruelty was never known among us.'" [1] Rather a heavy punishment for alleged hog stealing.

And now Underhill planned a crowning achievement. Visiting Stamford, he learned that the natives had assembled to a large number. With one hundred forty men, piloted by a renegade Indian, he landed at Greenwich where a heavy blizzard compelled him to remain all night. In the morning he marched to the northwest over stony and steep hills until evening, when he arrived within three miles of the village. Here he waited till ten o'clock and then advanced, reaching the Indian stronghold at midnight. The Indians were all alert and awake, so the whites divided into small bands and attacked the lodges. In a short time one hundred eighty warriors lay dead outside; the rest were cooped up in the houses. At La Montagne's suggestion these were fired. The savages tried every means to escape but when they could not, preferred the flames to falling into the hands of Underhill and his Christian followers. About seven hundred of the enemy, including twenty-five visiting Wappingers, were burned or shot, and not one woman or child was heard to scream or cry. Underhill, diligently as he searched his Bible, never seems to have seen some passages which might have justified more humane action.

The Sint-sinct, Weckquaesgeck, Nochpeem, Wappinger and others after this calamitous defeat begged for peace, and later the Matinecock of Long Island and the Hackensack and Tappan treated with the Dutch, and the Indian war of 1641–45 was ended.

Sixteen hundred Indians were killed, it is said, and the Dutch exclaimed, "Our fields lie fallow and waste, our dwellings and other buildings are burnt, not a handful can be planted or sown this fall on all the abandoned places. All this through a foolish hankering after war; for it is known to all right thinking men here that these Indians have lived as lambs among us until a few years ago, injuring no one, and affording every assistance." [2]

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[1] Documentary History, IV, 105.

[2] Colonial History, 1 : 210.

For a time things again assumed a peaceful basis, the Indians coming in to New Amsterdam to trade as of old. However, the Dutch could not resist the temptation to cheat and defraud, nor the Indians to drink, and constant friction resulted.

Stuyvesant, who succeeded Kieft, was a better and more diplomatic man, and was more successful with the native tribes. In 1665, however, war broke out again. Hendrick Van Dyck, ex-schout-fiscal of New Amsterdam, lived at what is now the west side of Broadway, near Bowling Green, next door to Paulus Linderstein Van der Grist. One afternoon in September Van Dyck saw an Indian woman picking peaches in his orchard, and, drawing his pistol, shot her dead. Stuyvesant had by his firm, truthful and just dealings with the Indians held them in peace and almost won their friendship, Van Dyck made an end of this by his cruel stupidity.

No notice was taken of the murder by the authorities despite the repeated complaints of the Indians. A war party of Wappinger was on its way to battle, and the local Indians begged their aid. On the 15th of September early in the morning, before scarcely any one had risen, sixty-four canoes containing five hundred armed warriors landed and scattered themselves through the town, and under the pretext of searching for their hereditary enemies, the Mohawk, forced entrance to the various houses. They offered no one any personal violence, however, and their chiefs even consent to attend a council with the governor where they promised to depart in the evening, some going to Governors island, but when evening arrived they returned, joined by two hundred more armed warriors. Landing at the Battery they went up Broadway to Van Dyck's home and there shot him dead with an arrow. Van der Grist, attempting to assist him, was tomahawked.

At this the Dutch burgher guard attacked the Indians without orders just as they were disembarking, and a sharp battle ensued with loss on both sides. The Indians withdrew to the west side of the river where they destroyed Hoboken and Pavonia, and later the settlement at Staten island. Fully fifty persons were killed and one hundred or more captured, and about eighty thousand dollars worth of damage was done. Stuyvesant was at South River when this outbreak occurred but returned as soon as he learned of the trouble. War parties of Indians were wandering all over Manhattan island and the Dutch were confined to the fort.

Upon Stuyvesant's return fortifications were strengthened and preparations were made to resist an assault, but the Indians were

satisfied. They sent Captain Pos, taken on Staten island, with propositions of ransom, but tired of waiting for his return they sent further word that in two days they would deliver all their prisoners to the Dutch at Paulus Hook. Pos went back and soon brought fourteen prisoners from the Hackensack camp with the report that the Indians desired some powder and ball in exchange. These Stuyvesant sent with two prisoners, a Wappinger and an Esopus, and promised more on the delivery of the rest of the captives.

Pos and two others took this message to the Indians, and brought back twenty-eight more prisoners and the intelligence that twenty others would be restored on the receipt of a ransom of powder and ball. Thirty-five pounds of powder and ten staves of lead which were demanded were sent and the prisoners were released. As Stuyvesant believed his people were at fault, he refused to punish the Indians, to the rage of the settlers. Of this outbreak the Long Island Indians denied any part. Indeed it is said that the war party which landed on Manhattan island was on its way to fight these Long Island tribes, and only stopped to avenge the murder by Van Dyck. Had the band been tactfully treated at the time the entire calamity might have been averted.

From this time on the scene of combat was changed to the Esopus country. The Manhattan, Hackensack, Raritan, and Canarsie seem to have taken little part in these troubles. The English under Richard Nicolls now took possession of Fort Amsterdam, which they called Fort James on September 6, 1664. Treaties were made by the English with all the local Indians and the alliance with the Iroquois was strengthened.

Little further trouble was had with the weakening savages who from this time on are rarely heard of as separate bands. Some became incorporated with the so-called "Schaticooks" who were made up of Indians partly from New England, and these often assisted the Mohawks and English against the French. Their descendants may still be seen on the Housatonic river in Connecticut.[1] Others were incorporated among the Delawares and their descendants are scattered in Canada, Wisconsin and Indian Territory. The name of Manhattan is now only a memory and the people who bore it are lost forever.

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[1] *See* Speck. Anthropological Papers, v. 3, p. 183: "The Mohegan Indians."

AUTHORITIES

Bayles. History of Staten Island.
Beauchamp. Aboriginal Occupation of New York.
Bolton, R. P. The Indians of Washington Heights, Anthropological Papers, 3: 77–109.
Calver, W. L. Personal Notes.
Chenoweth, Alexander. Collections and Notes in Museum.
Clute. History of Staten Island.
Davis, W. T. Personal Notes.
De Vries, David Pieteirz. Journal.
Finch, J. K. Aboriginal Remains on Manhattan Island, Anthropological Papers, 3: 65–73.
Fiske. The Dutch and Quaker Colonies in America, v. 1.
Harrington, M. R. Personal Notes and Manuscripts; *also* The Rock-Shelters of Armonk, New York, Anthropological Papers, 3: 125–38; Ancient Shell Heaps near New York City, Anthropological Papers, 3: 169–79.
Juet. Journal of Hudson's Voyage.
O'Callaghan. Documentary History of New York.
Pepper, George H. Personal Notes.
Ruttenber. Indian Tribes of Hudson's River.
Skinner, Alanson. The Lenapé Indians of Staten Island, Anthropological Papers, 3: 3–62.
Speck, F. G. Notes on the Mohegan and Niantic Indians, Anthropological Papers, 3: 183–210.

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Museum Bulletin 159

THE MINERAL SPRINGS OF SARATOGA

BY

JAMES F. KEMP

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Science Division, January 20, 1912

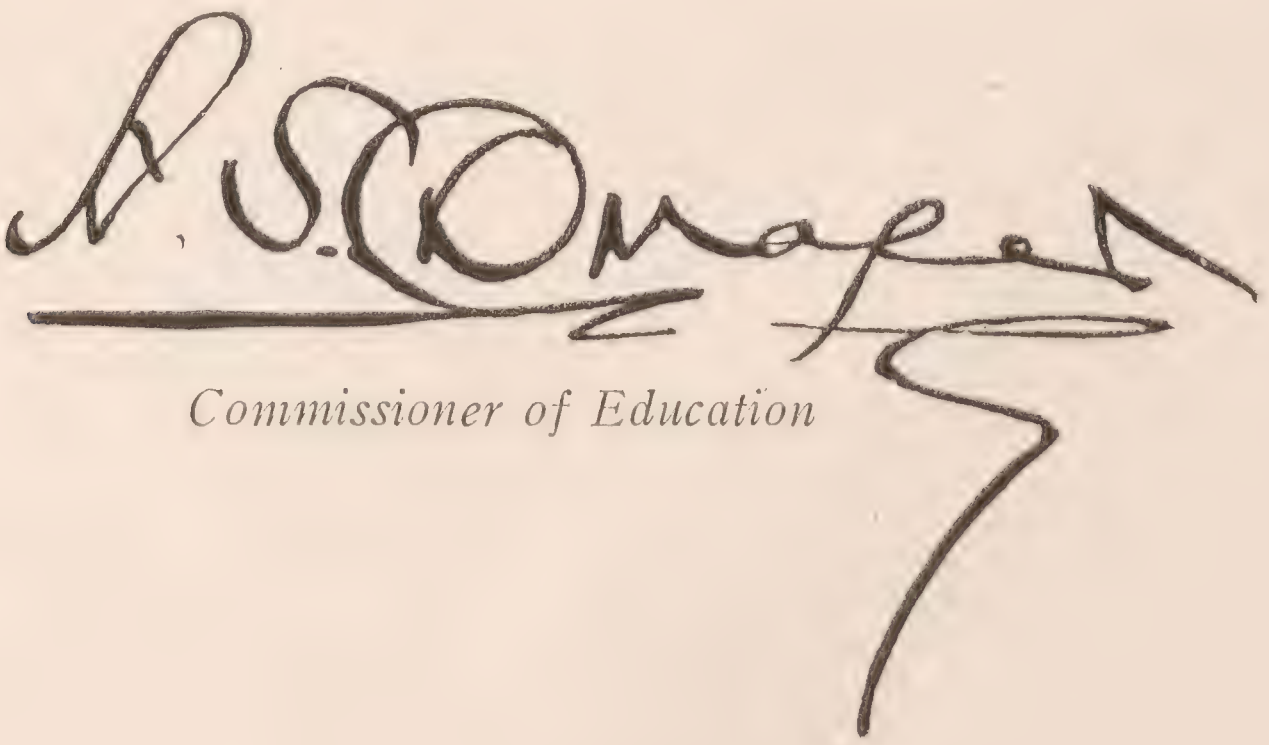
Honorable Andrew S. Draper LL.D.
Commissioner of Education

SIR: I have the honor to transmit to you herewith a manuscript report on the *Mineral Springs of Saratoga* which has been prepared at my request by Professor James F. Kemp, expert member of this staff, and I recommend the publication of this report as a bulletin of the State Museum.

Very respectfully
JOHN M. CLARKE
Director

STATE OF NEW YORK
EDUCATION DEPARTMENT
COMMISSIONER'S ROOM

Approved for publication this 20th day of January 1912



Commissioner of Education

Figure 1 Outline Map of Mineral Springs Albany to Glens Falls

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THE MINERAL SPRINGS OF SARATOGA

BY

JAMES F. KEMP

INTRODUCTION

This paper was originally written as a chapter for the bulletin upon the geology of the Saratoga Springs quadrangle which is being prepared by H. P. Cushing and R. Ruedemann. To both these geologists the writer is greatly indebted. The local geology will be set forth by them in due season. To Professor Cushing special acknowledgments should be made for the invitation, extended with the approval of the State Geologist, Doctor Clarke, to join him in the Saratoga work.

Assistance from the Hon. Edgar T. Brackett and Mr J. C. Minor, jr, in connection with books, early records, analyses and the like, has been received to a degree that has aided greatly in bringing together the necessary but widely scattered data. The writer's thanks are due to both these gentlemen.

With regard to the source of the mineral matter and gases in the springs, the writer has consulted many papers not specifically cited. Acknowledgments may be made at this point to those of A. Gautier, "Annales des Mines," 9:316, 1906; F. C. Lincoln, "Magmatic Emanations," Economic Geology, 2:258, 1907; R. T. Chamberlin "The Gases in Rocks," Carnegie Institution, 1908, and to the recent volume of A. Brun, "Recherches sur l'exhalaison volcanique," Geneva, 1911.

HISTORICAL SKETCH

The mineral springs of Saratoga first attracted the attention of the white settlers soon after the middle of the eighteenth century. In early colonial days they were westward of the first line of settle-

ments and off the main line of such travel as there was between the valley of the Hudson and the valleys of Lake Champlain and the St Lawrence. The colonists, naturally, established themselves first in the valley of the Hudson and their earliest settlements in this region were some ten miles to the east of Saratoga Springs. The line of communication between the French villages in the valley of the St Lawrence and the Dutch and English colonists in and around Albany, whether used for peaceful or hostile purposes, also followed this main waterway. The springs were in the heart of the Mohawk hunting grounds and their salty waters undoubtedly attracted the wild animals before they caught the eye of the Indian. So far as we know, the High Rock spring was first discovered. Its mound of calcareous tufa would naturally be more conspicuous than the mere uprising of water and gas from a crevice in the rock. The High Rock was in the midst of a depressed area, at the foot of a rock escarpment and along the west side of a brook. While the smaller features are disguised by the village improvements of today, the rock bench is conspicuous, and the larger features can easily be restored in one's imagination. About a century after its discovery by the whites, a pit was sunk below the High Rock mound with the hope of cleaning the conduit and increasing the flow. It is recorded that the excavators found the mound itself resting upon two pairs of crossed logs. The logs were supported by muck and tufa, the whole forming a section of seven feet. Still lower were two feet of tufa, then one foot of muck with another log, then three feet of tufa, beneath which were charred sticks, the remains of a fire.[1] Evidence of this sort would suggest the presence of primitive man some thousands of years before the advent of the whites.

Of the identity of the first white man who viewed the High Rock spring we may not be assured. There is some reason to think that a wounded French soldier was the pioneer. But the first one whose visit attracted special attention was Sir William Johnson, the picturesque character, whose life is intimately associated with the early history of the Mohawk valley. Sir William afflicted with a bodily ailment went to the High Rock spring in 1767. His stay benefited him and he aided much in directing attention to the waters. Four years later the first cabin was built near the spring itself and then the long procession of distinguished visitors was well under way. In 1783, Generals Washington, Schuyler and Hamilton with Gov-

[1] A sketch and cross section appears in a paper by Dr Charles F. Chandler, in the American Chemist for December 1871, page 204.

ernor Clinton honored the primitive watering place with their presence. Four years later came Dr Samuel L. Mitchill, who was for many years the leading scientific man in New York. Accommodations improved, but in the earlier years Ballston Spa was more sought than Saratoga Springs.[1] In the early part of the nineteenth century the tide of travel again turned to Saratoga Springs and has held this course ever since.

As early as 1770 the medicinal properties of the waters were commented upon by Doctor Constable of Schenectady, and in 1793, in volume 2, page 1, of the Memoirs of the American Academy of Arts and Sciences, was published a letter from Dr Samuel Tenney, a regimental surgeon, at Saratoga. In the same year appeared a "Dissertation upon the Mineral Waters of Saratoga," by Dr Valentine Seaman of New York. In the course of the next century a rather extended series of papers and separate books was devoted to this subject, and it is to be hoped that with the development of the springs as a health resort of increasing prominence the curative properties of the waters and the attractions of the beautiful village and surrounding country will be more and more widely known.

The following chronological list[2] gives the dates when the older and better known springs were discovered as natural flowing vents, or were developed with the drill:

High Rock	1767	Pavilion	1839	Eureka	1868
Red Spring	1784	United States	1839	Geyser	1870
Congress	1792	Empire	1846	Crystal	1870
Columbian	1805	Excelsior	1859	Champion	1871
Hamilton	1806	Saratoga A	1865	Vichy	1872
Washington	1806	Seltzer	1865	Kissingen	1872
Putnam	1835	Union	1868	Hathorn No. 2	1890
Star	1835	Hathorn	1868	No. 3	1905

[1] It is important to discriminate properly between Saratoga and Saratoga Springs. Saratoga is a town on the banks of the Hudson. Along its western boundary lies Saratoga Springs which is a separate town and village. Saratoga on the river was settled over fifty years before the springs attracted the attention of the whites. The battle of Saratoga was named from the eastern township, not from the springs. The fame of the springs has so far overshadowed the older settlement as to cause some confusion of mind among persons at a distance.

[2] This list is taken chiefly from a work compiled by the local newspaper, the Saratogan, and entitled, Our County and its People, page 390, 1899.

This is not a complete list of the springs. There are, for example, northeast of the village and about a mile from the High Rock, the Ten springs, or Excelsior, and the Eureka White Sulphur group. Opposite Congress Park, across Broadway, is the Ainsworth. To the south are the Chief, Adams and Arondack (formerly the Kissingen) besides many drilled wells. The accompanying map gives all these locations and several others not specifically referred to.

In Ballston Spa, mineral springs were known toward the close of the eighteenth century. The modern ones, however, come up through drill holes which are put down through slate to the limestone at depths varying from 604 to 715 feet. There are four now active, namely, the Iron springs, not possessing much if any gas at present, the Artesian Lithia, Hide's Franklin and a new one recently opened called the Washington.

In the 1835 edition of the work of Dr J. H. Steel entitled "Analysis of the Mineral Waters of Saratoga and Ballston," it is stated that the Quaker springs are situated ten miles southeast of Saratoga Springs and that they contain lime, magnesia, iron, and a certain percentage of common salt and soda. The gaseous contents are small in comparison with those already described; their mineral impregnation is not sufficient to entitle them to much attention.

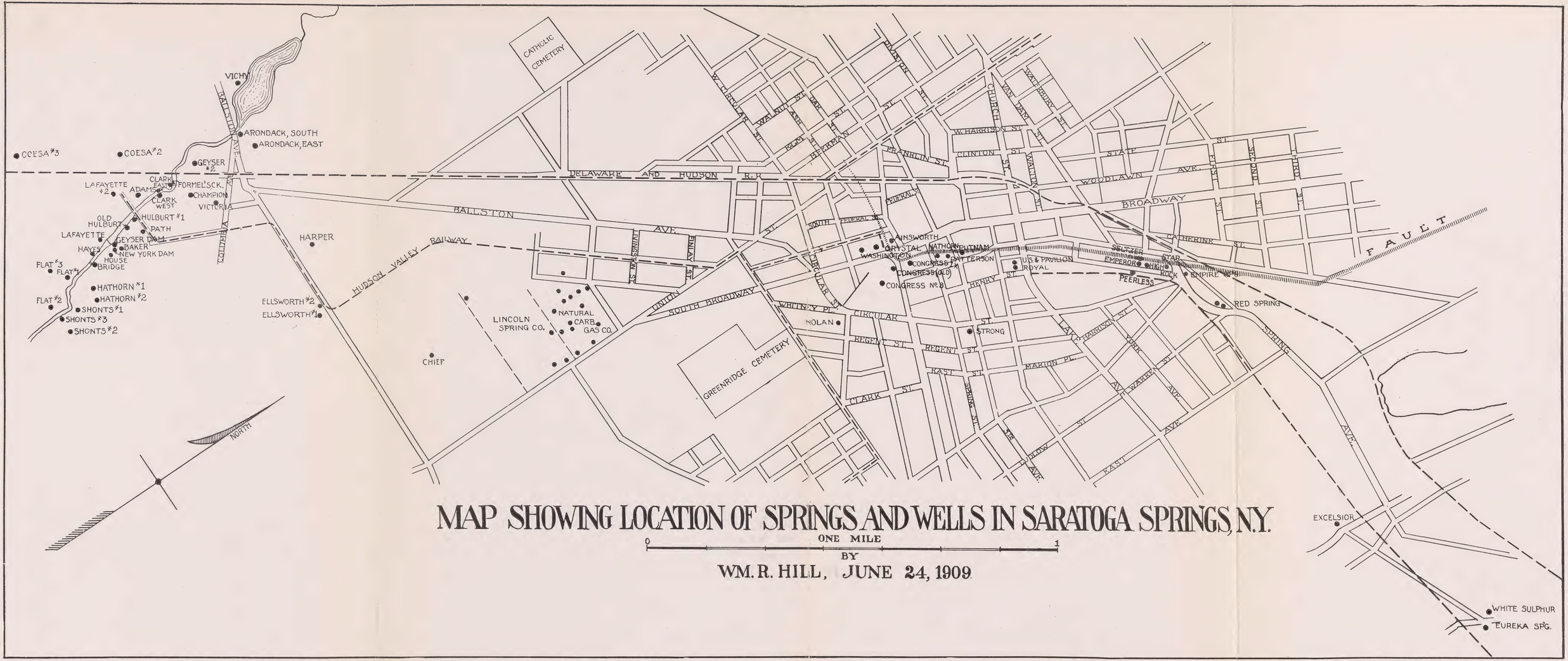
These springs still exist and are feeble in their manifestations of activity. A few bubbles of carbonic acid gas and of sulfuretted hydrogen come through the waters.

In Mather's Report on the First District, New York State Geological Survey, 1843, page 103, there is the following record of Reed's mineral spring:

> This spring is in South Argyle, Washington county, near the Moses kill. It is an acidulous carbonated water, something like the Saratoga waters, but the gas does not escape very abundantly from the fountain. Bubbles of carbonic acid gas rise from the bottom of the fountain at short intervals, and the water has a pleasant acidulous taste, but it does not sparkle. It is resorted to by the people around and many ride there from Saratoga to drink the water for a change. It is a pleasant acidulous water. It is used by the people of the vicinity for raising their dough preparatory to baking it, no yeast being required. . . . The spring rises from a fissure in limestone near its junction with slate rocks, which are metamorphic, or belong to the Taconic division of rocks.

This spring must have been on the east side of the Hudson river and at least fifteen miles northeast of Saratoga Springs.

The most northerly of all the springs now important is the Gurn, eight miles from the village of Saratoga Springs. It is very actively



MAP SHOWING LOCATION OF SPRINGS AND WELLS IN SARATOGA SPRINGS, N.Y.

0 ONE MILE 1

BY

WM. R. HILL, JUNE 24, 1909

flowing, well carbonated and of the same general composition as the Saratoga waters. An analysis is given later.

Still farther north in the village of Whitehall, thirty-nine miles from Saratoga Springs, is a spring called the "Adirondack," feebly carbonated and of greatly contrasted composition to the Saratoga waters in that it contains less of sodium chlorid than of either calcium or magnesium carbonate, and almost as much calcium sulphate. The total dissolved solids is only about one-eighth or one-tenth that of the Saratoga waters. (Bulletin 32, U. S. Geol. Survey, pages 27 and 32, 1886.)

To the south the mineral waters have been discovered even beyond Ballston. Thus, at Round Lake, in 1875, a drill hole was put down which reached a total depth of 1403 feet. At a point below 1300 there was struck a flow of water of composition not unlike the Saratoga waters. Its analysis is given later. The hole was torpedoed, however, and after the explosion the flow was lost.

In 1827, a well was even drilled in Albany 500 feet deep, on Ferry street, and yielded carbonated waters of the general composition of those at Saratoga Springs (L. C. Beck, Mineralogy of New York, 1841, page 138). An analysis is cited later. Albany is forty miles from Saratoga, and respectively thirty-two and twenty-six from Ballston and Round Lake. No other drilled wells have been recorded in the interval from Round Lake to Albany.

Thus waters, carbonated and of a somewhat similar composition are known over a stretch of approximately forty miles in a general north and south direction from Albany to Gurn springs, or if we include the Adirondack springs, at Whitehall, of about sixty-five miles. Between Albany and Round Lake, a distance of twenty miles, none are known. And again from the Gurn spring to Whitehall, a distance of thirty miles, none have been reported. These statements are in a measure useful in connection with general geographical conceptions, but they are not expressed in a way to be of geological significance. The springs should be grouped in northeast and southwest lines, along the known faults or fault systems. Apparently then, the Ballston-Saratoga Springs-Gurn series are to be taken on one line, with perhaps the Whitehall spring at the extreme north. The Round Lake well is five miles to the east of this line; the Quaker springs eight miles; Reed's spring in South Argyle, eight or more; and the Albany well nearly fifteen miles east of its southern prolongation.

BRIEF STATEMENT OF THE LOCAL GEOLOGY

The careful work of Professor Cushing and Doctor Ruedemann has established the following section of the strata at Saratoga Springs, from above down:

The Canajoharie shales (formerly called the Hudson River or sometimes the Utica slates). Of unknown but great thickness.

The Amsterdam limestone (formerly called the Trenton limestone). ..... 50′

A very important erosion interval represented in the Champlain valley by the Chazy limestone 300 feet thick, and the upper part of the Beekmantown (formerly called the Calciferous sandrock) 1200 feet. Land conditions seem to have prevailed in the Saratoga region.

Little Falls dolomite (the lower member of the Beekmantown or Calciferous). ..... 300′+

Hoyt limestone (formerly called the Saratoga limestone)... 100′

Theresa passage beds, alternate limey and sandy layers.....50′–75′

Potsdam sandstone or quartzite.....200′ or less

Grenville series of ancient gneisses and metamorphic rocks with intrusive igneous masses.....Indefinitely thick

Exclusive of the shales or slates at the top, which are above the productive horizon of the mineral waters, we have thus about 500 feet of limestones and dolomites, resting upon 200 feet or less of hard sandstones, and these upon the ancient metamorphosed gneisses, granites etc., which were formerly collectively described as Laurentian or Archean.

When tapped by the drill the mineral waters are chiefly obtained from the Little Falls dolomite. When the drill has penetrated the slates it strikes the waters, if such are found at all, in limestones, not far below the underside of the slates. It is possible that in some instances this may be in the Amsterdam (or old Trenton), but where the drill cores or the drillings have been identified, it is easy to recognize them as belonging to the Little Falls dolomite. The drilled wells in Saratoga Springs itself start either in the slates or in the Amsterdam (Trenton) limestone, but quickly pass through one or both of these and enter the Little Falls dolomite. In the Congress diamond drill core, which has been preserved and is available for study, the following section was disclosed:

Gravel	18′ 2″
Amsterdam limestone	16′
Little Falls dolomite	283′
Total	317′ 2″

The Hathorn drilled well penetrated to a depth of 1006 feet, of which the last few feet are reported as Potsdam. This rock is so easy to identify that there can be little question that the drill stopped in it, but the determination of the other members needs revision, and the cores are unfortunately no longer available. The depth of the well shows so much in excess of the general section as given above that there may be repetition from faulting.

The farther east wells are drilled at Saratoga Springs from the line of Spring street, the thicker the slate will be found. At Doctor Strong's sanatorium after 86 feet of gravel, nearly 300 feet of slate are reported before the limestone was met.

The drilled wells of the gas companies and the holes for mineral water at the Geysers, two miles south of Saratoga Springs, begin in the Canajoharie (Hudson River) slates. They find the waters, however, in the underlying limestones. The holes run between 300 and 400 feet deep at the General Carbonic Company's wells. The farther south one goes, the greater is the thickness of slate. Thus, at Ballston, it is 600 or 700 feet and at Round Lake between 1300 and 1400 feet.

To the north of Saratoga the Gurn spring apparently emerges from the Little Falls dolomite. The vent is some feet below the capping of gravel and is no longer visible, but the nearest outcrops are all of the dolomite.

Of the geological history of the district from the close of the time marked by the formation of the slates — that is, from the later Ordovicic period — we have but scant records, as will be set forth in the report of Professor Cushing and Doctor Ruedemann. Whether other sediments once covered the slates and were then removed by erosion is doubtful. The lack of sediments suggests land conditions at least for the greater part of the time. The strata shared in the mountainous uplifts to some extent, but near the springs the dips are still very flat and notable folds are not immediately concerned with them. Important faulting has taken place and one fault in particular, as will next be described, has an intimate relationship to the springs. The dips next the

faults show a drag down to the southeast on the western side of the break, and an upward drag on the eastern, or dropped side. As the fault escarpments are the more prominent outcrops one could easily gain the impression that the inclination was all to the southeast, but Cushing and Ruedemann find the predominant dips in between the faults to be flat to the west or northwest. The sinking of the surface and of the strata themselves, toward the low points of the region, Saratoga lake and the Hudson river, seems therefore largely due to faulting and to the greater erosion of the soft slates by the continental ice sheet. The geological age of the faults is obscure. They may at least have been the scene of renewed movement in fairly recent geological time.

At some time in this long interval the volcanic plug at Northumberland was developed, but the quarrying operations of the years 1910–11 have revealed some obscure and puzzling relations which will be fully discussed by Professor Cushing in a forthcoming bulletin.

The advent of the Continental glaciers from the north and in very recent geological time has served to spread over the region a heavy mantle of gravel and sand, such that the rocky strata are often buried beneath as much as 150 feet of loose deposits. From the bedrock the natural springs usually emerge into this gravel and sand and then find their way to the surface. Doubtless there are others which have never been discovered and which become lost in the general ground waters. Where they have been observed it has been usual to sink through the gravel to the bedrock, find the orifice and conduct the water to the surface in some sort of a tube which has been cemented tightly to the rock around the crevice.

Various estimates have been made of the time which has elapsed since the recession of the ice sheet. They vary from 10,000 to 50,000 years. If the section revealed in excavating beneath the High Rock mound is correctly interpreted there must have accumulated some 13 feet of tufa and muck since the aborigines built a fire; apparently also since the great ice sheet had scraped the bedrock clear.

THE FAULT AT SARATOGA SPRINGS

A structural feature of the local geology which early claimed attention is the fault which runs along just west of the main line of the springs in Saratoga village. It is revealed by a cliff of Little Falls dolomite some 30 or 40 feet high and with precipitous front except where partially or wholly covered by earth. The fault has

been traced by Cushing and Ruedemann to the north across the sheet as their map will show. To the south its exact course is obscured by the glacial drift and sands, but it seems to make a westward swerve at Congress street and Broadway and turn along Oak street after which it may turn south again, but its exact course is hidden by the drift.

The fault as it appears west of the springs along Spring avenue is not one of great displacement. The Little Falls (Beekmantown) dolomite forms the cliff to the westward and possesses the characters of the upper portion of this particular stratum. As it is followed northward beyond the Maple avenue quarries the Amsterdam (Trenton) limestone still remains on top of it, proving that the top of the escarpment is near the upper limit of the dolomite.

At the foot of the escarpment and in the rear of the Star spring bottling works, Cushing and Ruedeman discovered a block of Amsterdam (Trenton) at the surface on the downthrown side. This fixes within fairly close limits the amount of the displacement at this point. If the cliff is about 30 feet and the thickness of the Amsterdam is 50 feet and some of the Amsterdam still remains beneath the surface on the east side, and if its bottom can not have been far above the top of the escarpment on the uplift side, we have 80 feet as an extreme possibility and 50 feet as a not improbable amount.

The displacement may be greater at other places along the fault line, but for so continuous a break it is impressive to find the throw so small. The Amsterdam limestone is soon succeeded by the slates to the eastward.

The most striking feature of the fault lies in the fact that no mineral spring has been discovered to the west of it, and where it can be sharply located no spring is known very far to the east of it. The Strong well is approximately 1100 feet from it; the Excelsior or Ten springs about 3000 feet. The wells of the Natural Carbonic Gas Co. and of the Lincoln Company are some similar distance if we give, as seems necessary, credit to the westward swerve along Oak street. The course of the fault being obscured by the drift, we do not know what its relations to the springs farther south may be. To the north the fault splits into two; the main one following the escarpment of the ancient crystalline rocks and a branch striking northeast toward the Gurn spring. This spring emerges a short distance from the branch fault.

As the springs are not found west of the known fault, it is important to remark that in the region of Saratoga village the slates also fail on this side. The Amsterdam limestone is indeed known, but the slates cease on its east side. Slates are, however, at the surface between the main fault and the Gurn spring branch, but only in limited exposure. Generally speaking, therefore, we may say that both springs and slate lie east of the fault and that the waters of carbonated and saline character apparently belonging to this series of springs have not been discovered more than three-quarters of a mile from its assured outcrop, whereas most of them are where the fault is known and within a few hundred feet of it. In this connection, however, attention should again be drawn to the weak Quaker springs, to Reeds spring in South Argyle, and to the Round Lake well, all of which are some miles east of this particular fault.

The line of springs along Spring avenue, in the village of Saratoga Springs, north and south of the High Rock, are not far from the 280 foot contour. The Hathorn and Congress to the south are a few feet higher but are under 300 feet. The springs west of the steam railway at the Geysers are both above and below the 300 foot contour but do not reach the 320. The Gurn spring is between the 280 and 300 foot contour.

At Ballston Spa, Hides Franklin comes out with a strong pressure at 276, but the other three are below the 260 foot contour.

West of Saratoga Springs and Ballston, the 300 foot contour speedily crosses even the lowest stream valleys and the general level for from two to five miles is between 300 and 400 feet. At Rock City Falls, seven miles due west of Saratoga Springs, the 500 foot contour crosses the main line of drainage, Kayaderosseras creek. Still farther in this direction and within the limits of the quadrangle the altitude attains 1000 feet and to the north, still within the quadrangle, the culmination is about 2000.

By contrast when we turn eastward, Saratoga lake, one important low point, stands at 204 and the Hudson river at 100. With such flat dipping strata even though the commoner dip is to the northwest rather than the southeast, the general course of the ground waters would be to the southeast, and such head as would exist in the normal ground water would be exerted in this direction. William R. Hill C. E., by a careful series of levelings upon the waters standing in the wells of the Natural Carbonic Gas and Lincoln Spring Companies at a time when no pumping was being done and the waters had resumed their normal positions, and by deter-

mining the resultant of his observations, reached the conclusion that the natural flow was in a direction s. 65 e. or 25 degrees south of east. While these expressions must be taken as general they undoubtedly express the truth.

GENERALITIES REGARDING THE NORMAL GROUND WATERS

The waters which are found beneath the surface of the earth are now regarded by students of the subject as of three kinds which are technically called:

1 Meteoric, derived from the rainfall.
2 Magmatic or Juvenile, derived from igneous rocks.
3 Connate, which as sea waters and lake waters saturate sediments and are buried with them.

1 **Meteoric waters.** This group embraces the waters of ordinary character and of general occurrence. The rain falls upon the earth and divides into three parts:

a A portion evaporates at once and passes back into the atmosphere.
b A portion runs off on the surface and helps directly to maintain the general drainage.
c A portion sinks into the ground through porous soils, cracks, or other cavities in the rocks and contributes to the "ground water."

The name "ground water" is applied to the subsurface waters which stand at a fairly constant level, wherever the rainfall is sufficient to maintain them, certainly in all but excessively arid regions. The ground water supplies wells, in which it is found in our climate at comparatively shallow depths. It supplies the ordinary springs, and in this way contributes to the drainage, acting as a reservoir and being tapped away at those low points, behind which there is sufficient head to force it to the surface. The movement of this reservoir of water as a whole is very slow, but at individual vents the emerging portion may flow rapidly. Experience in recent years with deep mines and bore holes has led to the belief that as a rule the ground water only attains a depth of 1000 or 2000 feet, since in sinking deep shafts the miners find that by impounding the waters in the upper levels and pumping from them, they pass through the wet zone, and at greater depths have no water at all to pump. Even the small amounts of water required in drilling have to be sent down from the surface or the upper levels. Estimates of the amount of water contained in the outer crust have therefore greatly

diminished in later years. Thus, in 1861 Delesse, a French geologist, by assuming a certain porosity for the strata and calculating the amount of water required to fill the cavities, reached the conclusion that, were all this water to be spread over the surface, it would make a layer 7500 feet deep.[1] Estimates by others will be found in the citations. They vary through the following values: C. S. Schlichter 1902, 3000–3500 feet; C. R. Van Hise 1904, 226 feet; Chamberlin and Salisbury 1903, 800 to 1600 feet.

The writer in 1901 endeavored to draw upon mining experience and upon deep boreholes in discussing the ground water and concluded that it extended as a rule to a depth of only 1000 to 2000 feet. If we allow 5 per cent for the voids in rock, this would mean a layer 50–100 feet; or if 10 per cent, 100–200 feet. Ten per cent is the extreme of voids in the most porous and 5 per cent is nearer a fair estimate, but these two values are usually employed.

M. L. Fuller of the United States Geological Survey in 1906, after a very extended experience with holes drilled for water, in his work upon the division of the Survey dealing with water supply, concluded that the ground water would amount to a layer 96 feet deep if it were spread out on the surface. At 5 per cent of cavities in the rocky strata, this would go down about 2000 feet, or at 10 per cent about 1000 feet. T. Sterry Hunt determined the cavities in the hard, white Postdam such as we have at Saratoga Springs to lie between 1.39 and 2.47 per cent of the volume. Less metamorphosed varieties yielded from 6.94 to 9.35. (Chemical and Geological Essays, p. 166, 1878.) These figures will help to make more definite in our minds the amount of water of this kind with which we have to deal.

The meteoric ground waters in their migrations through the rocky strata dissolve some mineral matter. The rain takes up a little carbonic acid gas from the atmosphere and has to this extent its solvent powers increased. It has also oxygen, nitrogen and other gases in far less amount. The dissolved air is higher in oxygen and carbonic acid and lower in nitrogen than is the ordinary atmosphere. Potash, soda, lime, magnesia, and iron dissolve most readily from the rocks. Silica is also taken in very small quantity, as are several other rock-making components. On the whole, lime is the most abundant and widespread of the dissolved bases, and in ordinary spring waters the dissolved matter varies from a minimum

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[1] M. L. Fuller. Total amount of water in the earth's crust. Water Supply and Irrigation Paper. U. S. Geol. Surv. 160. p. 59, 1906.

of 5 grains to a maximum of about 50 grains per U. S. gallon of 231 cubic inches. These values are practically equivalent to from 85 to 850 parts in a million. If we keep some such general figures as these in mind we can carry along an idea as to the way the mineral springs under discussion compare with ordinary waters. Saratoga waters range from a minimum of 300 to a maximum of about 1200 grains of dissolved solids per gallon.

Regarding the movement of waters through the crevices of the rocks, the friction greatly increases with the decrease of the diameter of the conduit. Thus if we deal with ordinary pipes, under a constant head, the friction increases inversely as the diameters. A pipe which has a diameter one-eighth that of another, develops eight times as much friction, and the friction operates to lessen the flow greatly.

2 **The magmatic waters.** Observers of volcanic eruptions have long been impressed with the vast amount of steam emitted under great pressure at times of outbreak. The explosive violence of the outbreaks has been chiefly attributed to it. In some instances only such gaseous emissions, together with shattered rock, issue from the crater, as was the case at Mont Pelee, Martinique, except for the solid spine which was forced out in the closing stages. Molten lava failed. Emissions of steam are also yielded, sometimes for months by consolidating lava streams which have already poured out on the surface. The amounts have at times been calculated and they are very impressive.

It was formerly a widespread belief that this water was derived from the ocean or from seas near whose shores volcanos are usually, but not invariably, situated. Geologists imagined that the sea water percolating downward and inward, was drawn by capillary attraction to the molten rock and became involved in its substance. This conception has seemed impossible to many later students of the subject who can not believe that water would or could be drawn through rock gradually becoming hotter and hotter, until the water successively passed its boiling point, its point of dissociation into oxygen and hydrogen and necessarily reached a temperature still higher by 1500 to 3000 degrees Fahrenheit before it could be absorbed by the molten rock. It seems to many at least that as soon as the water encountered temperatures much above its boiling point it would be driven outward. The writer therefore rejects the oceanic source of

the water manifested in volcanic eruptions as too improbable to deserve confidence. Water locked up in hydrated silicates which are melted into a rising flood of fused rock might become involved. Possibly confined reservoirs of artesian water which had no escape might also be absorbed, but it seems still more reasonable to think of the water gas, the carbonic acid and the other gases as original component parts of the magma, belonging to it as much as the silica and the common run of bases.

The presence of this water is still further shown by the effects exerted upon limestones where penetrated by masses of molten rock which have never reached the surface. So many new minerals have been produced partly from the limestone and partly by contributions from the igneous mass, that the agency of magmatic waters has been invoked by almost all students of the subject in order to explain the results.

In regions of dying volcanic activity, hot springs and emissions both of carbonic acid gas and of carbonated waters are the rule. Where the composition of the waters is markedly different from the composition of the rocks through which they rise, some observers have seen reason to attribute to them a deep-seated magmatic source. Carlsbad, Bohemia, with its springs rich in lime, arising from granite, a rock extremely poor in lime, is a famous case in point. Deep-seated magmatic waters have seemed to some observers the simplest explanation.

The waters are presumably evicted from the molten mass in its process of crystallization into the anhydrous silicates which make up the ordinary igneous rock. Obviously existing first as gases in the deep-seated mass, they pass with loss of heat into the liquid form and furnish hot springs and in their later stages possibly cold ones. The waters were called "juvenile" by E. Suess, the venerable Austrian geologist, because they reach the surface for the first time and therefore are young, or newly born. In America the name magmatic is somewhat more current.

In the most recent of the more important contributions to this subject,[1] P. Brun gives a number of analyses of gases which he has collected from regions of dying volcanic activity. He fails to find water gas in notable quantity, but does detect much hydrochloric acid. He concludes that the vapors which have been hitherto observed arising from volcanic vents are ammonium chlorid and

[1] P. Brun. Recherches sur l'exhalaison volcaniques, Geneva, 1911. The work is summarized in English by Alex. Winchell in Economic Geology.

other gases, together with finely divided dust, but not steam. Mr Brun's results have made a deep impression and so far as they go, are opposed to magmatic waters. They are however so different from the hundreds of analyses made before him by competent chemists, that many, including the writer, still adhere to the views set forth above.

We have as yet no sharp chemical criteria with which to distinguish magmatic waters from meteoric, except perhaps that carbonic acid is, as a matter of observation, when present in copious supply, usually in a region of dying volcanic activity. F. C. Lincoln has made a careful review of the records and has arranged the results in fifty representative analyses. He then finds that the gases when averaged from the fifty cases are, in the order of abundance, and expressed in parts per hundred:

Nitrogen (N_2)	44.360
Carbon dioxid (CO_2)	36.303
Oxygen (O_2)	9.026
Sulfuretted hydrogen (H_2S)	4.991
Hydrochloric acid (HCl)	2.057
Hydrogen (H_2)	1.601
Sulfur dioxid (SO_2)	.966
Marsh gas (CH_4)	.638
Carbon monoxid (CO)	.032
Ethane (C_2H_4)	.001

Of the nongaseous matters, water is much the commonest, constituting up to 95 per cent of the total condensed. In the above figures some, probably a rather important portion, of the nitrogen and oxygen is due to the admixture of atmospheric air in the sample. Since carbon dioxid only forms .03 per cent of atmospheric air, very little of it can have been derived from this source.

These statements regarding the magmatic waters are made, not with the idea of presenting a brief in their advocacy, but because they are significant and must be considered in any discussion of mineral springs.

3 **Connate waters.** Connate is a name recently applied by A. C. Lane to those waters which are, so to speak, born with the rocks which contain them, and which, absorbed by sediments during deposition, are carried down with the sediments when the latter are buried beneath other accumulations. If the sediments are marine, oceanic

waters will remain in them. If they are lacustrine, fresh water will be absorbed. The common brines found by the drill in old marine deposits are undoubtedly connate, but their preservation is largely due to being inclosed between impervious beds above and below. When we deal with fresh-water sediments the connate waters do not have great difference in composition from the ordinary meteoric ground waters. In judging of marine connate waters it is important to bear in mind that some geologists think the sea to have been a less concentrated solution in its early history, and in the very remote times represented, for instance by the Grenville series of the Saratoga section, that it was comparatively fresh. Rivers have indeed been pouring into it their burden of dissolved materials and as these are not removed by evaporation, except to the extent in which they are driven over the land in spray caught up from breaking waves by the wind, the conclusion has followed that the sea is like a great evaporating pan, constantly becoming more concentrated. One line of attack upon the problem of estimating the age of the earth has been to assume fresh-water oceans and calculate from the known composition and volume of rivers the time required to bring the oceanic waters up to their present concentration.

On the other hand, there are geologists, notably Edouard Suess in Vienna, and R. T. Hill in New York, who urge that the oceans themselves were fed by magmatic waters from volcanos or their equivalents, in the early history of our planet, and that, as is well known regarding some volcanic waters, the salt was also furnished in this way. These views are at least worthy of respect; they seriously affect calculations of the age of the earth, although they do not conflict with the belief in weaker oceanic waters in the remote past. Connate waters underground almost inevitably are subject to admixtures of meteoric ground waters.

THE COMPOSITION AND CHARACTER OF THE SARATOGA WATERS

Having established the general conceptions regarding underground waters, we may next take up the composition of the local mineral springs and their place among mineral waters as found in nature. Many analyses have been prepared in the last seventy-five years or more and a considerable number within the last ten. A few introductory remarks may be made upon analyses in general and the methods of reporting the results, before the actual waters are discussed.

The analysis of a water is conducted by taking a suitable and carefully measured sample from the spring and evaporating it to dryness so as to secure the dissolved matter. The composition of the evaporated residue is then determined by the chemist. It must be remembered that the residue from a water such as is afforded by the Saratoga springs is a complex mixture containing a number of bases and acids, each of which is determined by itself. Thus in the Saratoga waters there have been customarily reported ten elements which are present in acids, namely, chlorin, bromin, iodin, fluorin, carbon, sulfur, phosphorus, boron, nitrogen and silicon. Each of these makes an acid of its own. Some ten elements furnish the bases, namely, sodium, potassium, lithium, magnesium, calcium, barium, strontium, iron, aluminum and manganese. With these must be placed the rarer ammonium and still rarer rubidium. When the chemists have determined these acids and bases they endeavor to combine the results as they believe them to exist in the original water. They do so on assumptions of the relative chemical affinities of the elements for one another and divide the acids among the bases so as to use up the supply of each. Probably the results represent with a fair degree of accuracy the combinations as found in the springs, but as subsequent discussion will show, there inevitably arise minor differences among chemists.

In later years the theory of ions has gained great support. According to this conception, the dissolved compounds exist in dilute solutions in the form of incomplete molecules, the same being held in this condition by electromotive force. The incomplete molecules are called ions. Thus, whereas in an older analysis, we would find reported $NaCl$, Na_2CO_3, (or $NaHCO_3$), $NaBr$, NaI, Na_3PO_4, KCl, K_2SO_4, $MgCO_3$ (or $Mg(HCO_3)_2$), $CaCO_3$ (or $Ca(HCO_3)_2$), CaF_2, $FeCO_3$ (or $Fe(HCO_3)_2$), $BaCO_3$ (or $Ba(HCO_3)_2$), Li_2CO_3 (or $Li(HCO_3)$, $SrCO_3$ (or $Sr(HCO_3)_2$), Al_2O_3, and SiO_2; in one in the last ten years we find, Cl, HCO_3, Br, I, PO_4, SO_4, Na, K, Mg, Ca, Fe, Ba, Li, Sr, Al and SiO_2. As a separate statement the latter authority might then combine them into salts but whereas as the earlier chemists sometimes calculated carbonates, such as Na_2CO_3, $MgCO_3$, $CaCO_3$, etc., the later analysis gives them all as bicarbonates, respectively $NaHCO_3$, $Mg(HCO_3)_2$, $Ca(HCO_3)_2$, etc. Each chemist determined boron — the former combined it with sodium as a biborate; the latter as a metaborate.

There is no very serious objection to either of these courses as above outlined. Fashions change among chemists as among other people, but the method of reporting by ions probably involves fewer

possibilities of mistaken assumptions. People at large, however, are not yet accustomed to these terms and an analysis in the newest form possesses for most readers less significance than one in the old style.

There are other differences in the methods of reporting analyses. The older method and the one most widely intelligible among those not skilled in chemistry, is to give the dissolved matter in grains per U. S. gallon of 231 cubic inches. More rarely, older analyses are expressed in grains per Imperial gallon of 277.272 cubic inches. The U. S. gallon contains 58,373[1] grains; the Imperial, 70,048.4 grains. Both involve the old system of apothecary's weights. In later years it is a growing custom to express the analysis in parts per million, a method which falls in best with the metric system, in which the analyses are universally made. We can roughly pass from the grains per U. S. gallon to parts per million by multiplying the former by 17,[2] or from parts per million to grains per gallon by dividing by 17. The writer much prefers parts per million, which is of course in the metric system milligrams per liter. Enough parallel values will, however, be given to make the statements significant to one accustomed to grains per gallon.

It may further be remarked that the total of solids actually weighed after evaporation of the sample is necessarily always less than the summation of the dissolved salts, where the latter are given as bicarbonates. The extra carbonic acid molecule or partial molecule of the bicarbonate passes off in evaporation.

Among the analyses made of the Saratoga waters in the last hundred years three groups may be established:

The oldest were principally performed by Dr John H. Steel, a physician resident of Saratoga Springs in the early years of the past century, and the first one to give the waters thorough scientific study. Doctor Steel published a book on the springs[3] in which

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[1] A. C. Peale, in his paper on the Mineral Springs of the United States in 14th Ann. Rept. U. S. Geol. Survey, p. 71, gives a U. S. gallon as 58,372 grains and the Imperial as 70,000 or 277 cubic inches.

[2] More accurately by 17.13. The reciprocal is .058.

[3] John H. Steel M. D. An Analysis of the Mineral Waters of Saratoga and Ballston, with Practical Remarks on their Medical Properties, etc. Saratoga Springs, 2d ed. 1838. Earlier imprints appeared in 1817 and 1825. The 1825 edition has a geological map. The strata are classified as: I Primitive class — granite, gneiss, syenite, mica slate and soapstone; II Transition class — argillaceous slate and gray-wacke; III Secondary class — compact limestone. A copy with the map is in the New York Public Library.

he brought together a series of analyses made in the 30's or earlier. With these in the chart, figure 2, have been combined a few others of this early time or of the next decade. All these analyses are compiled in the tables at the close of this bulletin.

The second group was made about thirty years later. Just before and just after 1870, Dr Charles F. Chandler prepared a very valuable list, representing nearly all the better known springs both in Saratoga and Ballston. They were chiefly published in the "American Chemist" for December 1871, page 203. As used here they are amplified by one or two made in 1871–73 which appear in Cairn's Quantitative Analysis. In 1905 or thereabouts the United States Department of Agriculture through its Bureau of Chemistry prepared an interesting series in connection with the investigation of mineral waters placed on sale throughout the country. Some of the samples were bought in the open market and a still larger series was obtained at the springs by a representative of the bureau.

Besides the analyses used in the charts, a number have been prepared at the request of owners of springs by chemists of standing and have been used in circulars or other advertising matter. They, so far as available, and all the ones used in the charts, have been compiled in the tables of analyses on pages 65–74. They are less significant than groups made by the same chemist, whose sampling and methods would be naturally more uniform, but they have value. One must also hold judgment somewhat in abeyance as regards the significance of analyses because of the artificial strengthening of natural waters both with salts and with carbonic acid. To some extent this has been done.

In all the general statements which follow, the total of dissolved solids is based on bicarbonates. These results, therefore, as earlier stated, will be somewhat higher than the weight of the residue obtained by evaporation. The extra molecule of carbonic acid is driven off on evaporation. The bicarbonate, however, probably represents the salt as it exists in solution. In the first set of curves only the most abundant of the dissolved salts are used, namely, NaCl, $Ca(HCO_3)_2$, $Mg(HCO_3)_2$ and $NaHCO_3$. The others will be commented upon but are too small to make much of a showing when plotted as curves.

In total dissolved solids the maximum found in the Saratoga waters by the earlier analysts is 11,215 parts in a million, reported for the Congress spring in 1843, by J. R. Chilton. The minimum is 3787, reported by J. H. Steel for the New Washington.

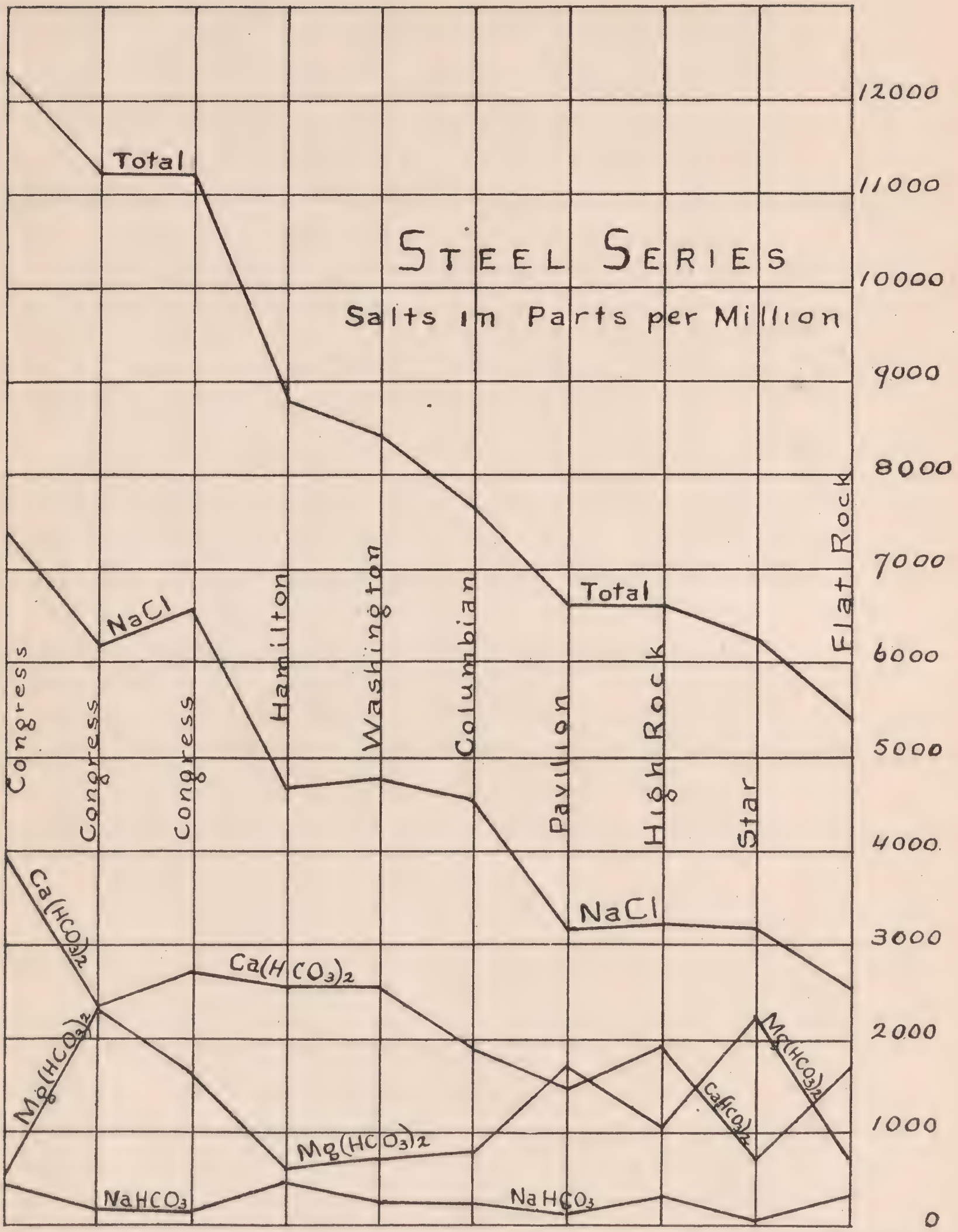

Figure 2 Diagram of dissolved salts based on the analyses of Dr John H. Steel, 1838. The horizontal lines indicate parts per million. Each vertical line represents one analysis.

In the series made by Dr Charles F. Chandler just before and just after 1870 the maximum was afforded by the Glacier Spouting well, at 20,325 parts in a million, or about 2 per cent. Next to this is the Geyser Spouting well with 16,856. The minimum was afforded by the Seltzer spring with 5134 parts.

In the series from the Department of Agriculture, the maximum is the Carlsbad, with 12,950; the minimum, the High Rock, with 2347.

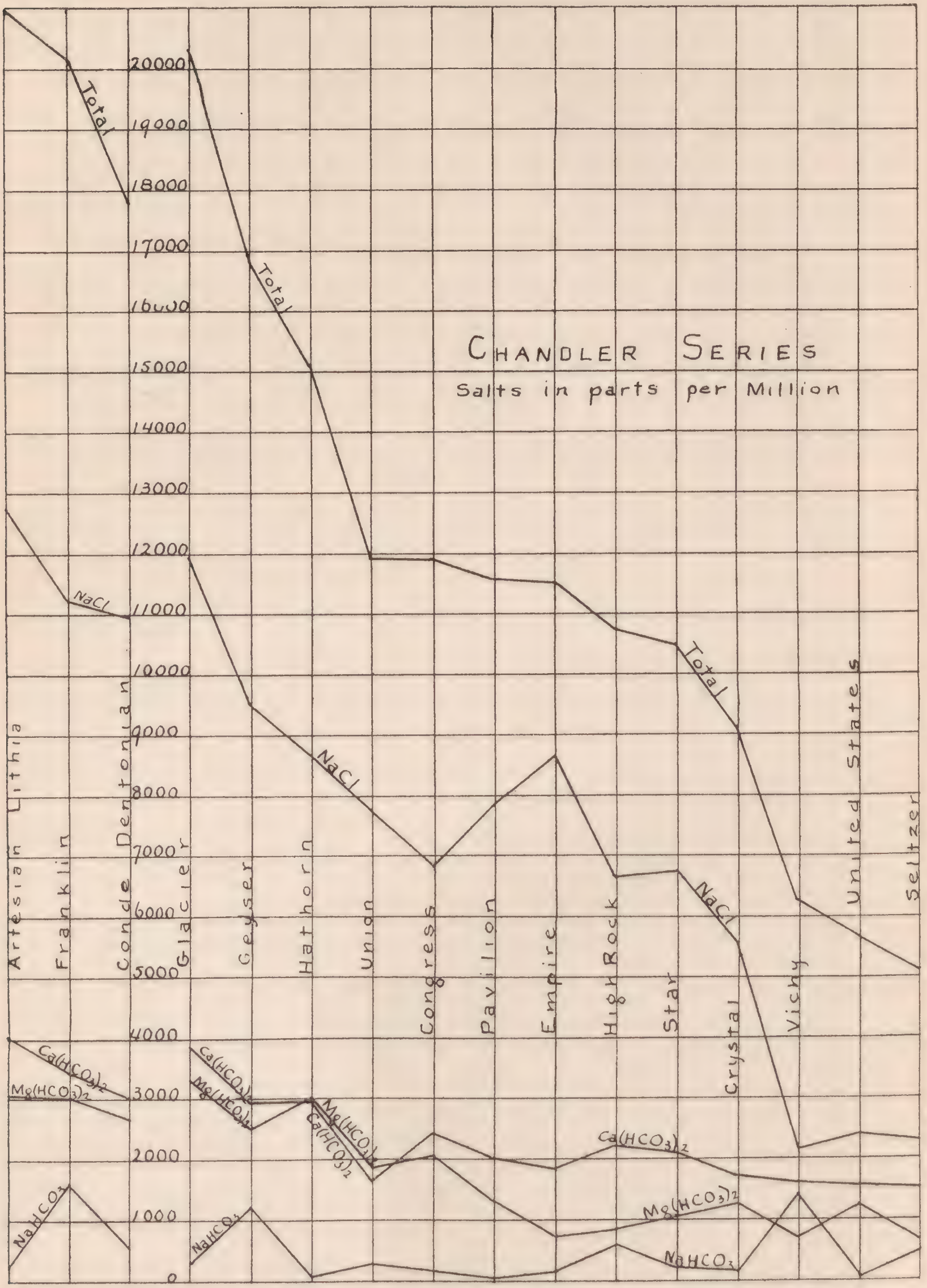

Figure 3 Diagram of dissolved salts based on the analyses of Dr Charles F. Chandler, 1873 The horizontal lines indicate parts per million. Each vertical line represents one analysis.

The State Department of Health has found in the new Hathorn No. 2, two miles or more south of the village, 16,350, and in the Champion spring only 1370.

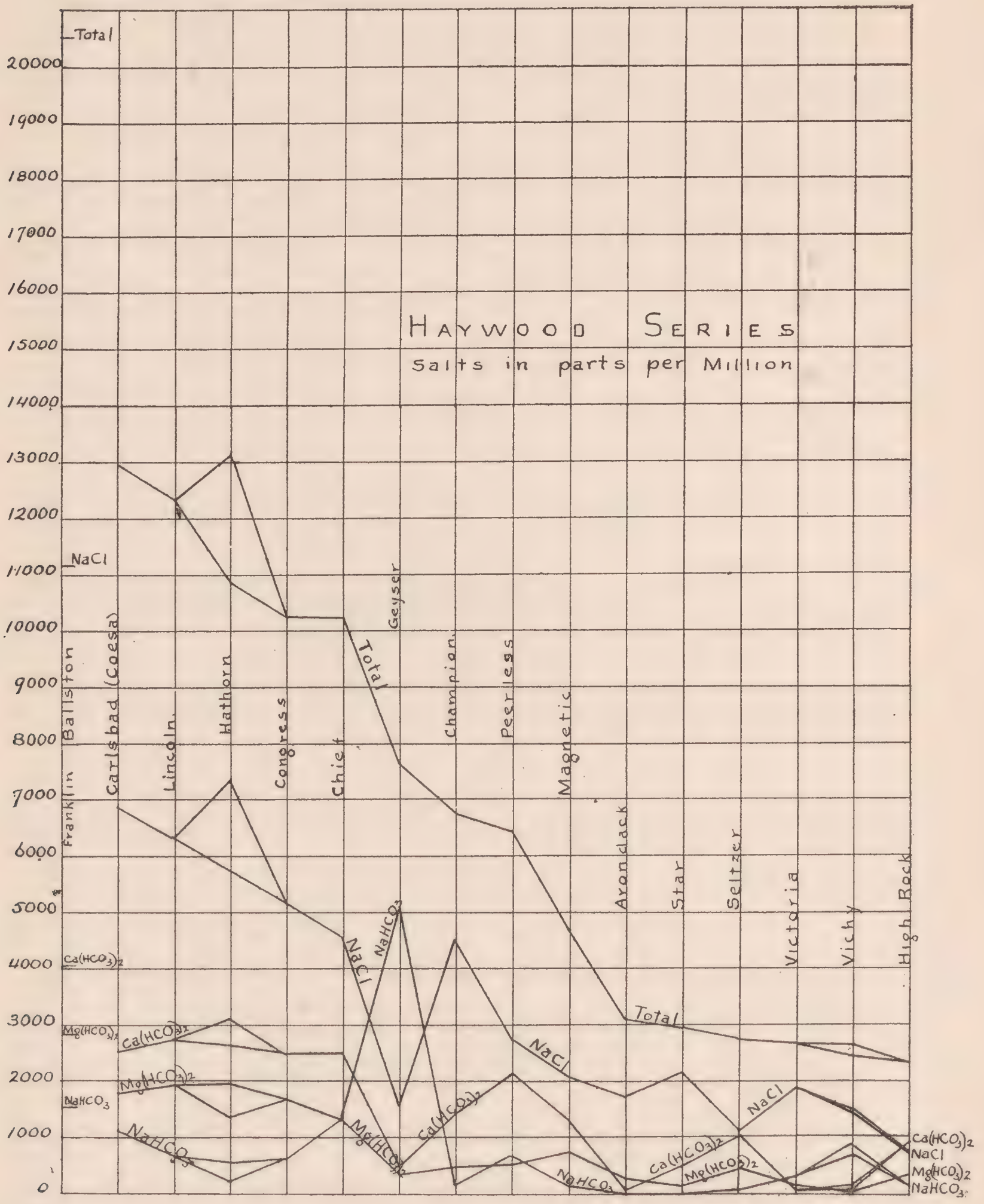

Figure 4 Diagram of dissolved salts based on the analyses of J. K. Haywood and B. H. Smith, of the United States Department of Agriculture, 1905. Each horizontal line indicates parts per million Each vertical line represents one analysis.

The Ballston waters give higher results than any above cited. Doctor Chandler found in the Artesian Lithia spring 20,965, and in

the Franklin 20,134. An analysis recently made of the latter spring by the Department of Agriculture gave 20,542.

These values will establish some conceptions of the extremes. A study of the diagrams will give a better impression of the mean or general composition. While not capable of definite expression, one finds it nevertheless helpful to formulate a general idea of this sort. Where, upon the charts, the curves take an approximately horizontal course, they indicate a number of analyses of nearly the same character, and if this feature is specially marked, values fairly typical of Saratoga may be looked for. In the oldest set of eight different springs, the totals of six lie between 6000 and 9000 parts in a million (353 to 530 grains to the gallon). In Doctor Chandler's series of thirteen analyses, representing a range from 5000 to 20,000 parts per million, six lie between 10,500 and 12,000. In the thirteen from the Department of Agriculture, there is an almost even decline from the maximum, about 13,000 down to 3100. There are then six between 2300 and 3100.

In every analysis known to the writer, save one, NaCl or common salt is the most abundant of the dissolved ingredients. The solitary exception is an analysis of Geyser water, made by the Department of Agriculture, in which $NaHCO_3$, sodium bicarbonate, 5058 parts, is more than three times the NaCl, sodium chlorid, 1588 parts. The Geyser water, however, as analyzed by Doctor Chandler, was normal. The analysis with the high percentage of sodium bicarbonate possesses more human than scientific interest. Except for this exceptional case the NaCl curve is with small variations sympathetic with the curve of total dissolved matter. The NaCl is from two and one-half to three times as abundant as the next salt, calcium bicarbonate, $Ca(HCO_3)_2$. The maxima and minima of NaCl are: earliest set — 7385 and 2531; Doctor Chandler's set — 11,938 and 2187; Department of Agriculture — 6873 and 738.

Next to the NaCl, the calcium bicarbonate, $Ca(HCO_3)_2$ and the magnesian bicarbonate $Mg(HCO_3)_2$ are the salts chiefly in evidence. They may best be discussed together. They display marked sympathy with each other, the $Mg(HCO_3)_2$ being usually somewhat less than the $Ca(HCO_3)_2$. Among the older analyses, the maxima are for the calcium and magnesium salts, respectively, 3966 and 2325. The minima are 714 and 544. In the analysis of the Star water, however, E. Emmons reports 714 and 2218, respectively; a relation which is extraordinary, as the subsequent analyses of Star water are both normal. Probably the separation of calcium and magnesium in the analysis was faulty. In Doctor Chandler's series,

the maxima are respectively 3860 and 3297; the minima 1528 and 685. In the Department of Agriculture series, 3098 and 1974; the minima 36 and 55.

In the oldest series of eight different waters the magnesium salt exceeds the calcium salt twice; in the Chandler series of thirteen waters, twice; in the Department of Agriculture series of fifteen waters, also twice, but each time in very small amounts, 104 to 236 and 36 to 130.

Since these heavily carbonated waters are immediately derived from a dolomitic limestone and are vigorous, natural solvents of both calcium and magnesium carbonate, the two salts are doubtless derived in very large part from the limestone. Their solubilities in carbonated waters are respectively at pressures of one atmosphere, 385 and 1310 per million for non-crystalline varieties.

Of the ratio of the calcium carbonate, $CaCO_3$, to the magnesium carbonate, $MgCO_3$, in the Little Falls dolomites we can not speak with accuracy, because different layers probably differ, but the rock undoubtedly has the calcium salt uniformly in excess of the magnesium. In pure dolomite the calcium carbonate bears a ratio to the magnesium carbonate of 1 to .768. In Doctor Chandler's series the ratios lie between 1 to .417 and 1 to 1.13; in the Department of Agriculture's between 1 to .255 and 1 to 3.61, but in the last case the quantities are very small, 36 and 130 parts per million respectively.

While in very small amounts and therefore not plotted in the charts the presence of barium and strontium bicarbonates with the closely related calcium salt should be mentioned. Strontium was detected by one of the early chemists and is mentioned as a trace; barium, however, escaped notice. In the Chandler series barium bicarbonate is mentioned in many analyses and varies from upper values of 35.4 parts in the Glacier Spouting well and 34.2 in the Geyser, respectively 2.08 and 2.01 grains per gallon, to a trace in the Seltzer. Strontium bicarbonate is rarer. While invariably reported its maximum was 7.2 parts in the Geyser (.425 grains per gallon) but it was only a trace in ten out of thirteen analyses. Obviously it is present in very small proportions. In the analyses from the Department of Agriculture the maximum barium bicarbonate was found in the Lincoln water, 22.1 parts in a million, but strangely with no strontium whatever. The values of the barium salt are then pretty well distributed in the other analyses down to none at all in two of the seventeen. Strontium bicarbonate was never found above a trace in seven analyses, and failed altogether in ten.

The last salt found abundant enough to plot on the charts was the bicarbonate of soda, $NaHCO_3$. In the oldest series of analyses it favors very small values, the maximum being 359 parts, the minimum, 54.4. In the Chandler series the maximum is 1409, the minimum 64.6. In the Department of Agriculture series we find the exceptional Geyser water with 5058, which may be rejected from serious consideration. Next to it is the Chief, 1367. In two none is reported whatever.

Following the salts mentioned, potassium chlorid, KCl, is the one which on the whole next merits attention. In the earliest analyses it was seldom calculated. Only one record has been made and that of the Red spring, 116.6 parts in a million (6.86 grains in a gallon) by Professor Appleton. Such little potassium as was reported by the early chemists was usually combined with bromin, but many times we find no mention of it at all. In the Chandler series potassium chlorid is uniformly reported and fails in no analysis. Its maximum is 686.5 parts per million (40.4 grains per gallon) in the Glacier Spouting well. Its minimum 22.1 (or 1.3 grains) in the Seltzer spring. Among the thirteen analyses one is between 600 and 700; one between 400 and 500; one between 200 and 300; eight between 100 and 200; and two less than 100. Obviously, the common experience is between 100 and 200, or between 6 and 12 grains per gallon. In the Department of Agriculture series of seventeen analyses potassium chlorid is uniformly reported; one, the maximum, exceeds 400 (Carlsbad water 415); five fall between 300 and 400; two between 200 and 300; two between 100 and 200; and seven below 100, the minimum being 7.2. A comparison of these two statistics leads to no very tangible conclusion.

In the earlier analyses the next salt in abundance after sodium bicarbonate is iron bicarbonate, more often reported as iron carbonate. It appears in thirteen out of sixteen analyses. If we express it uniformly as bicarbonate we find that in six analyses it exceeds 100 parts in a million (maximum 148.2); in seven analyses it is below 100, the minimum being a trace. In the Chandler series iron bicarbonate is uniformly reported. Its maximum value is 43.7 parts per million, its minimum is .9. In the Department of Agriculture series the iron is sometimes given as bicarbonate and sometimes as ferric oxid with alumina. The maximum of the bicarbonate is 132.9, the minimum, none at all, that is no iron whatever was found in one case. Where expressed as the oxid with

alumina, the maximum is 80 in the same sample as the maximum bicarbonate.

It may be remarked that in the later development of the springs, deep-drilled holes are increasingly abundant and are cased with iron pipe. A small trace of iron might thus be contributed, as we are in any event dealing with quantities extremely small.

Iron in any form is not specially welcome to the purveyors of table waters, because, on standing, it separates as the hydrated ferric oxid and imparts a brown cloudiness to the water. This can be prevented by the slight addition of some harmless acid, such as citric, which keeps the iron in solution.

Manganese is an element so closely akin to iron that it may be mentioned here. It is not reported in any of the older analyses nor in the Chandler series, nor in the ones by other chemists recorded by A. C. Peale in Bulletin 32 of the United States Geological Survey. In the Department of Agriculture series it is but once mentioned as a trace.[1] Two analyses are quoted in "Our County and its People," page 401, of the Putnam spring. 8.23 parts per million (.484 grains per gallon), Lincoln spring 1.72 parts (.101 grains per gallon), but the analysts are not given.

Obviously the amount is very small and practically negligible as a factor in the general total.

The haloid elements bromin and iodin were very early discovered. Both are almost always mentioned in the older series of analyses. The bromin was usually assigned to potassium and expressed as potassium bromid. While ordinarily a mere trace, when combined with sodium iodid the sum for the Congress spring in one case was 100.6 parts in a million (5.92 grains in a gallon). Sodium iodid ranges from 30 to 60 parts per million with a maximum reported for the Empire spring by E. Emmons of 204 (12 grains per gallon).

In the Chandler analyses the bromin and iodin when recast were both assigned to sodium, all the potassium being given as chlorid or sulphate. The maximum elementary bromin is 112.9 parts per million (6.64 grains per gallon) equivalent to 145.5 parts of sodium bromid (8.56 grains per gallon) in the Congress spring. The minimum is 1.82 (.107 grains per gallon), corresponding to 4.52 (.266 grains) sodium bromid in the Empire. The maximum elementary

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[1] In the analysis of the Seltzer water, page 92, Bulletin Bureau of Chemistry, no. 91, it is calculated as Mn_3O_4. 7.3, although not mentioned in the elementary analysis which has the same total.

iodin is 8.67 parts (.51 grains) or expressed as sodium iodid, 10.30 parts (.606 grains) in the Empire. The minimum is a trace.

In the Department of Agriculture series the maximum elementary bromin is 76 parts in a million, corresponding to 113 parts of potassium bromid, in the Lincoln spring. The minimum was a trace in the Vichy spring. All these analyses are recast to the potassium salt. The iodin is much less. Its maximum elementary is 1.9, corresponding to potassium iodid 2.5 in the Lincoln. Its minimum is none at all.

The remaining haloid element, fluorine, was not reported in any of the earlier analyses, but it is almost always mentioned as a trace and assigned to calcium as calcium fluorid in the Chandler series. Fluorine is not mentioned in the analyses from the Department of Agriculture. Obviously when present its amount is extremely small, almost beyond the detection of ordinary analysis.

The presence of sulphates was noted by the early chemists who mention them in four out of sixteen analyses. In these, the sulfuric acid is assigned to sodium sulphate (Na_2SO_4) and ranges in amount from 28.56 parts in a million to 11.0 (1.68 grains in a gallon to .65). In one case it was calculated as magnesium sulphate, with .85 parts (or .05 grains). In the Chandler series it is always assigned to potassium sulphate and varies from 91.8 parts in the Star spring to a trace in several others (5.4 grains to a trace). In the Department of Agriculture series sodium sulphate is used. The maximum is 444.9 parts (26.2 grains) in the Arondack water, and the minimum 2.1 parts (.12 grains) in the Geyser.

Lithium is an element whose presence is greatly desired by the purveyors of mineral waters because of its supposed medicinal value. It does not fail in the Saratoga waters, but is in the customary small amounts. It was reported in only one case by the older chemists, in the Red spring, with 16.6 parts of lithium bicarbonate in the million (.94 grains in a gallon). As the bicarbonate it is mentioned in weighable amounts in all the Chandler analyses, varying from 194.6 parts in a million in the Hathorn (11.45 grains per gallon) to 15.3 as the lower limit (.9 grains per gallon) in the Seltzer. In the Department of Agriculture series the lithium is recast as lithium chlorid which is about six times the elementary lithium, whereas the lithium bicarbonate is nearly ten times. The maximum lithium chlorid reported is 44.9 parts in a million, but in a later analysis of the same water only 3 parts were found. In the seventeen analyses, two lie between 30 and 40 parts; one between 20 and 30; four between 10 and 20; and eight are less than 10, one

being a trace. These figures mean from a maximum of 2.64 grains in a gallon, to a trace.

Phosphoric acid was detected in two cases by the early chemists and was assigned to calcium as $Ca_3(PO_4)_2$ each time by the same chemist. The amounts were 3.57 and 3.23 parts per million of calcium phosphate. In the Chandler series the phosphoric acid is assigned to the sodium, and when reckoned as sodium phosphate ranges from a maximum of .44 parts in a million (.026 grains in a gallon) to a trace in five out of thirteen cases. In the Department of Agriculture series the phosphoric acid radicle (PO_4) was only found once in seventeen cases; all the rest gave none. Calculated as calcium phosphate $Ca_3(PO_4)_2$ it was 3.8 parts in a million (.22 grains per gallon).

Boron in some form of boracic acid has been occasionally reported. None of the older chemists detected it. In the Chandler series it is calculated as biborate of soda, and is reported as a trace in every analysis, never exceeding this value. In the analyses from the Department of Agriculture none at all was found in three of the seventeen cases, but in the other fourteen it varies from a small amount to a trace. It was in no case actually weighed as its determination in small quantities is difficult.

Alumina was recognized by the early chemists and was reported in seven out of sixteen analyses. Its maximum was 26.69 parts in a million (1.57 grains in a gallon) in the Union spring and its minimum a trace in three cases. It is always mentioned in the Chandler series and varies from a superior value of 20.8 parts in a million (1.22 grains per gallon) in the High Rock, to a trace in three cases. The analyses of the Department of Agriculture are not expressed so as to be of much service. Elementary aluminum is combined with elementary iron. These are sometimes recast as the combined oxids, and sometimes a portion of the iron is apparently assumed and calculated as bicarbonate. The combined elements range from a maximum of 97.8 parts in a million (5.8 grains per gallon) in the Magnetic (partly recast as 80 parts Fe_2O_3, Al_2O_3, and 132.9 parts $Fe(HCO_3)_2$) to a minimum of .8 (.05 grains per gallon) in the Champion. The Magnetic spring is, however, very exceptional. The next value to it is 14.7, so that the general range is approximately from 15 to 1.

Silica was recognized by the early chemists and was mentioned in eleven out of sixteen cases. It ranged from 55.25 parts in a million (3.25 grains per gallon) to a trace. It is always reported by Doctor Chandler and has a maximum of 54.6 parts per million (3.2

grains per gallon) in the Crystal spring and a minimum of 11.3 parts (.66 grains per gallon) in the Geyser. In the Department of Agriculture series, silica is always reported. Its maximum of 42.7 parts (2.5 grains) is in the Magnetic. The minimum of 9.2 parts (.54 grains) is in the Arondack. The values are quite uniformly distributed between these values. Once in the Vichy spring, a portion of the silica is recast into 27.6 parts of calcium metasilicate, CaO,SiO_2.

In one of the older analyses, made by J. R. Chilton of the Washington spring, 3.4 parts in a million (.2 grains per gallon) of calcium chlorid, $CaCl_2$, are reported, and 11.56 parts of magnesium chlorid, $MgCl_2$ (.68 grains), but the later analysts do not estimate these salts. Aside from the ones already passed in review, no other determinations of solids were made by the early chemists.

In the Chandler series organic matter is mentioned as a trace in every analysis, but no other solids are recorded than the ones already discussed.

In the series from the Department of Agriculture organic matter as such does not appear, but several determinations not reported in the two earliest groups of analyses are mentioned. Ammonium was found in every case and when expressed as ammonium chlorid, NH_4Cl, it ranges from a maximum of 39.67 parts in a million in the Carlsbad water (2.33 grains per gallon) to a minimum of .15 parts in the Victoria. The radicles of both nitric (NO_3) and nitrous (NO_2) acids are uniformly given. When recast as sodium nitrate, $NaNO_3$, we find 60.7 parts for the Star, followed by 16.3 for the Arondack, 9 for the High Rock, 6 for the Seltzer and a trace or none at all for the other thirteen. Sodium nitrite, $NaNO_2$, appears as 44.3 parts per million likewise for the Star, 11.9 for the Arondack, 6.6 for the High Rock, 4.4 for the Seltzer, and a trace or none for all the rest. Occasionally in analyses of other chemists whose work is not used in the above review, potassium nitrate is mentioned but the amount is always small. The presence of these salts in notable amount is so exceptional in the waters as to raise a query in the minds of close students.

The above review will make clear in a general way the ranges of composition in dissolved salts as shown by the waters at different times and by different chemists. The current remarks will bring out also the variations of waters of this type and the changes in the course of some seventy-five years, except in so far as the obvious gradual weakening may have been compensated in later time by artificial additions. A brief summary and tabulation of the maxima

and minima may now be given. All the values are in parts per million. Divide by 17 for grains per gallon.

Salt.	EARLY ANALYSES 1820–1850		C. F. CHANDLER 1860–1875		DEP'T OF AGRICULTURE 1902–1905	
	Max.	Min.	Max.	Min.	Max.	Min.
Total solids	11,215	3787.	20,325	5134.	12,950	2347.
NaCl	7385	2531.	11,938	2187.	6873	738.
KCl	116.6		686.8	22.1	415	7.2
KBr NaI	100.6	tr.				
NaI	204.		10.30	tr.		
NaBr			145.5	4.52		
KBr					113.	tr.
KI					2.5	None
LiCl					44.9	tr.
NH_4Cl					39.67	.15
CaF_2			tr.			
$CaCl_2$	3.4					
$MgCl_2$	11.56					
$Ca(HCO_3)_2$	3966.	714.	3860.	1528.	3098.	36.
$Mg(HCO_3)_2$	2325.	544.	3297.	685.	1974.	55.
$Ba(HCO_3)_2$			35.4	tr.	22.1	None
$Sr(HCO_3)_2$	tr.	tr.	7.2	tr.	tr.	None
$Fe(HCO_3)_2$	145.2	tr.	43.7	.9	132.9	None
$Mn(HCO_3)_2$					tr.	None
$NaHCO_3$	459.	54.4	1409.	64.6	5058.	None
					1367.	
$LiHCO_3$	16.		194.6	15.3		
Na_2SO_4	28.56	11.			444.9	2.1
K_2SO_4			91.8	tr.		
$MgSO_4$	.85					
$NaNO_3$	28.56				60.7	None
$NaNO_2$					44.3	None
$Ca_3(PO_4)_2$	3.57				3.8	None
$Na_6(PO_4)_2$			.44	tr.		
$Na_2B_2O_4$			tr.	tr.		
$NaBO_2$					small amt.	None
Al_2O_3	26.69	tr.	20.8	tr.		
Al_2O_3, Fe_2O_3					80.	
SiO_2	55.25	tr.	54.6	11.3	42.7	9.2
$CaSiO_3$					27.6	None
Organic matter			tr.	tr.		

Besides the compounds quoted in the three series of analyses, one may find in the occasional commercial analysis the following additional ones: calcium sulphate, potassium nitrate, potassium silicate, sodium silicate, boracic acid and ortho-silicic acid. The only additional element is rubidium which, as the chlorid, is cited as a trace in an analysis of the Sans Souci spring of Ballston in " Our County and its People," page 408, no chemist being mentioned.

As stated in the general remarks on chemical analyses, there is much room for assumption in recasting analyses to compounds. It will be of interest therefore to summarize briefly the relative abundance of the elements or acid radicles. The values will be taken only from the Chandler series of analyses and those of the Department of Agriculture. In all cases the chlorine is the most abundant elementary substance, except in the extraordinary instance of the Geyser analysis in the latter series, whose sodium bicarbonate proportion is so high as to give it no scientific value. The sodium follows after the chlorine, and as a rule the calcium and magnesium come next, the calcium usually in excess. Potassium is next and is succeeded by bromine, barium and lithium. The other elements are very small. Ammonium although not an element, behaves like one, and in the Department of Agriculture series on the whole ranks barium. Silica, also not elementary, precedes barium. Iron and aluminum together come approximately between silica above and barium below. If we calculate the carbonic acid of the bicarbonates as HCO_3 it may, in waters with high lime and magnesia, exceed the chlorin and be the highest value of all. If we consider also the gas that escapes, it is the most abundant dissolved substance as the water exists two or three hundred feet beneath the surface.

Since it is difficult to follow variations of so many substances, a series of curves has been plotted and is shown in figures 5–8 inclusive. Analyses are sometimes prepared of the evaporated residues. They are then expressed in percentages of the total residue. They are very significant in being simpler than parts per million in the water itself. They also enable one to judge critically the amount of the commoner ingredients. As the concluding table of analyses at the close of this bulletin (p. 75, 76) a compilation of those which have appeared up to date is given. It was chiefly made by Mr J. C. Minor, jr. To Mr Minor's records one or two recent analyses have been added.

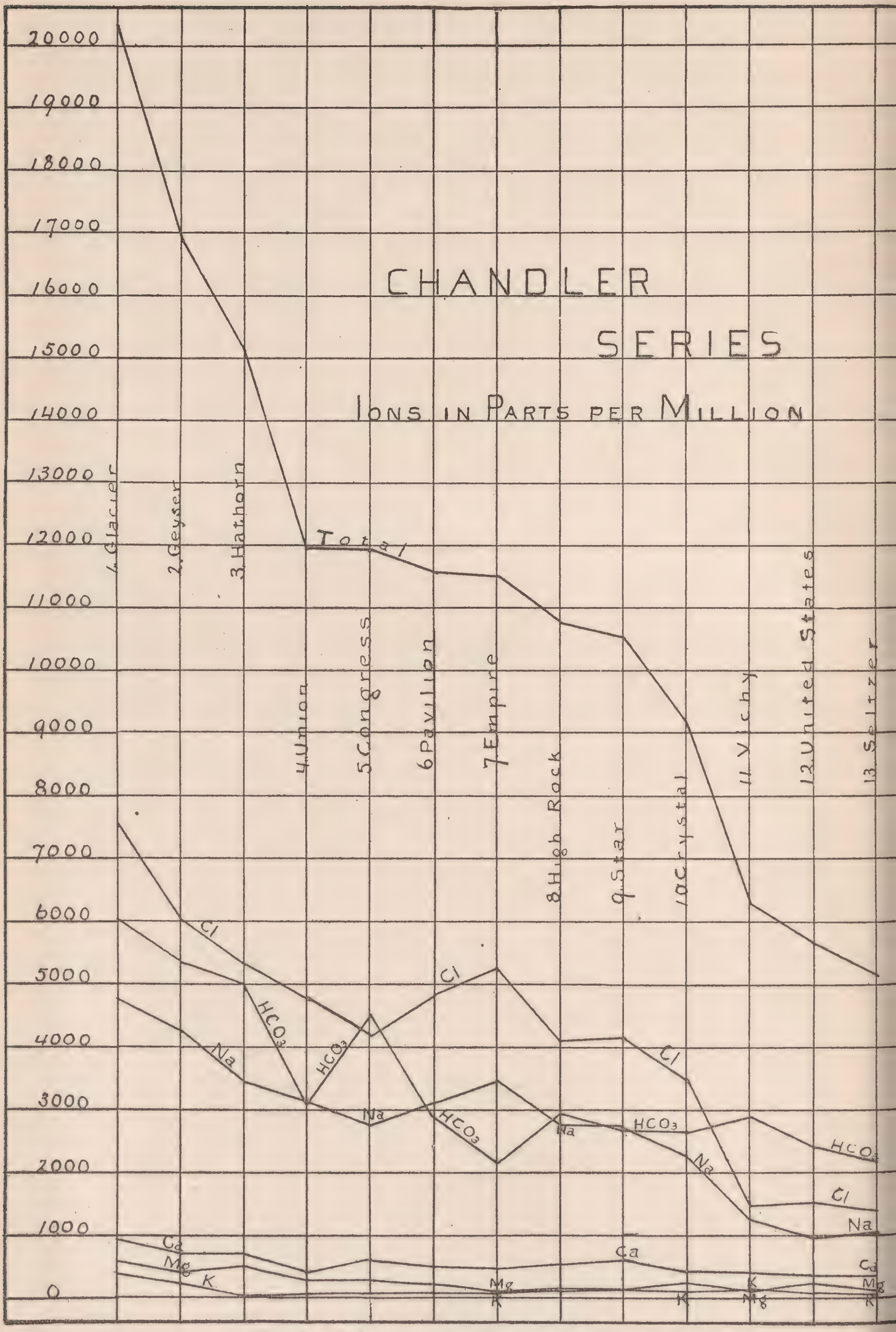

Figure 5 Diagrams of ions in parts per million

When statistics are prepared of these analyses, the following results become apparent. There are 66 analyses:

	Maximum	Minimum	General Range
NaCl	87.	21.2	45–60
$Ca(HCO_3)_2$	40.6	1.4	15–30
$Mg(HCO_3)_2$	27.9	2.3	5–20
$NaHCO_3$	67.3	.6	1–15
KCl	11.2	.4	1–5

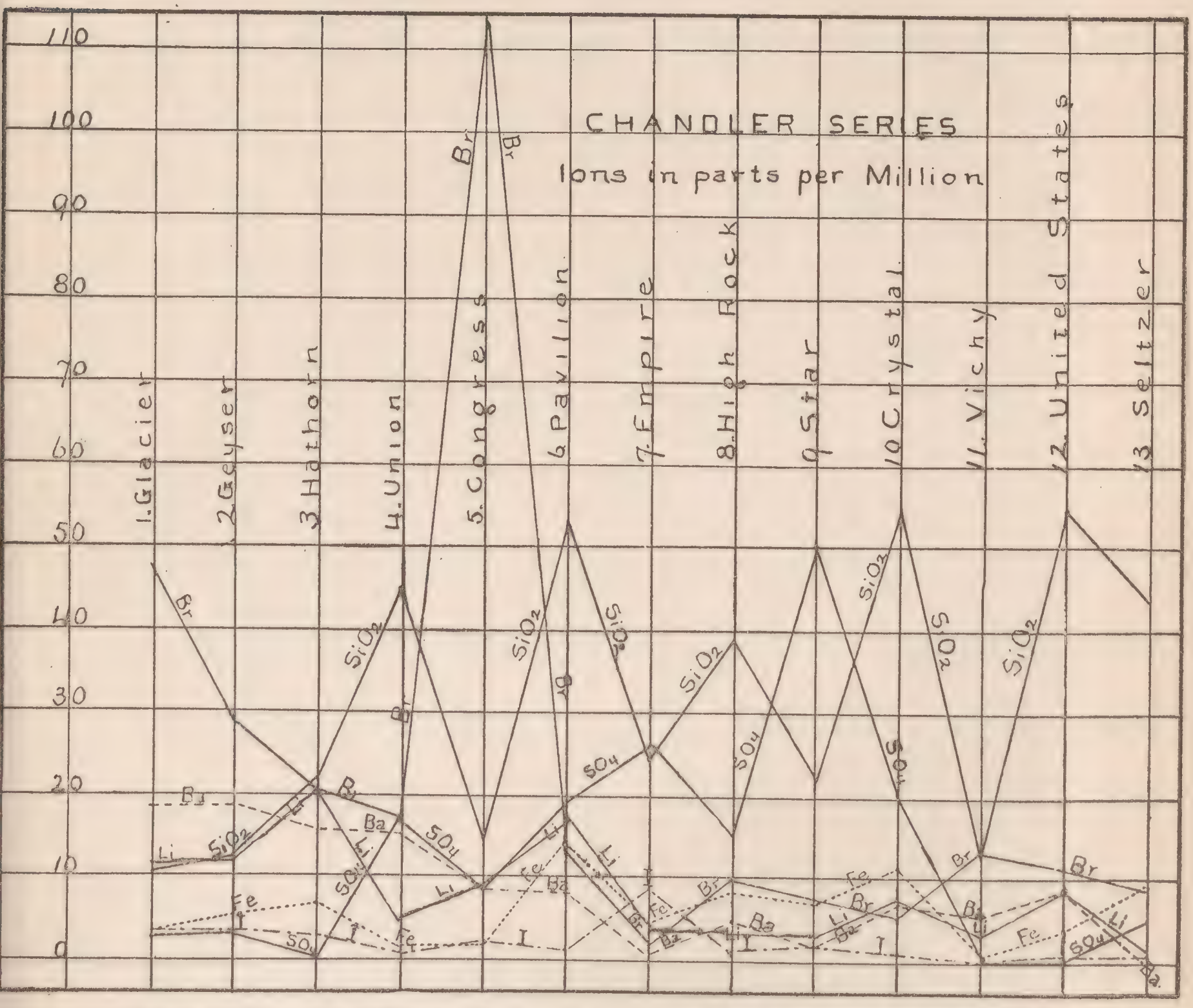

Figure 6 Diagrams of the rarer ions on an exaggerated scale as compared with figure 5

The extremely high values of NaCl are probably due to artificial strengthening. The minimum is due to the artificial addition of $NaHCO_3$, which relatively decreased the NaCl. NaCl above 60 per cent is an object of suspicion. The maximum, 40.6 of $Ca(HCO_3)_2$ is from a recent analysis of the High Rock. The next value is 40.4, of the Red spring. Then follow, 40.3 of the Magnetic and 38.6 of the Flat rock. All these have low total grains in the gallon, being respectively 129.4, 249.3, 214.7, and 253.8. All are from springs in

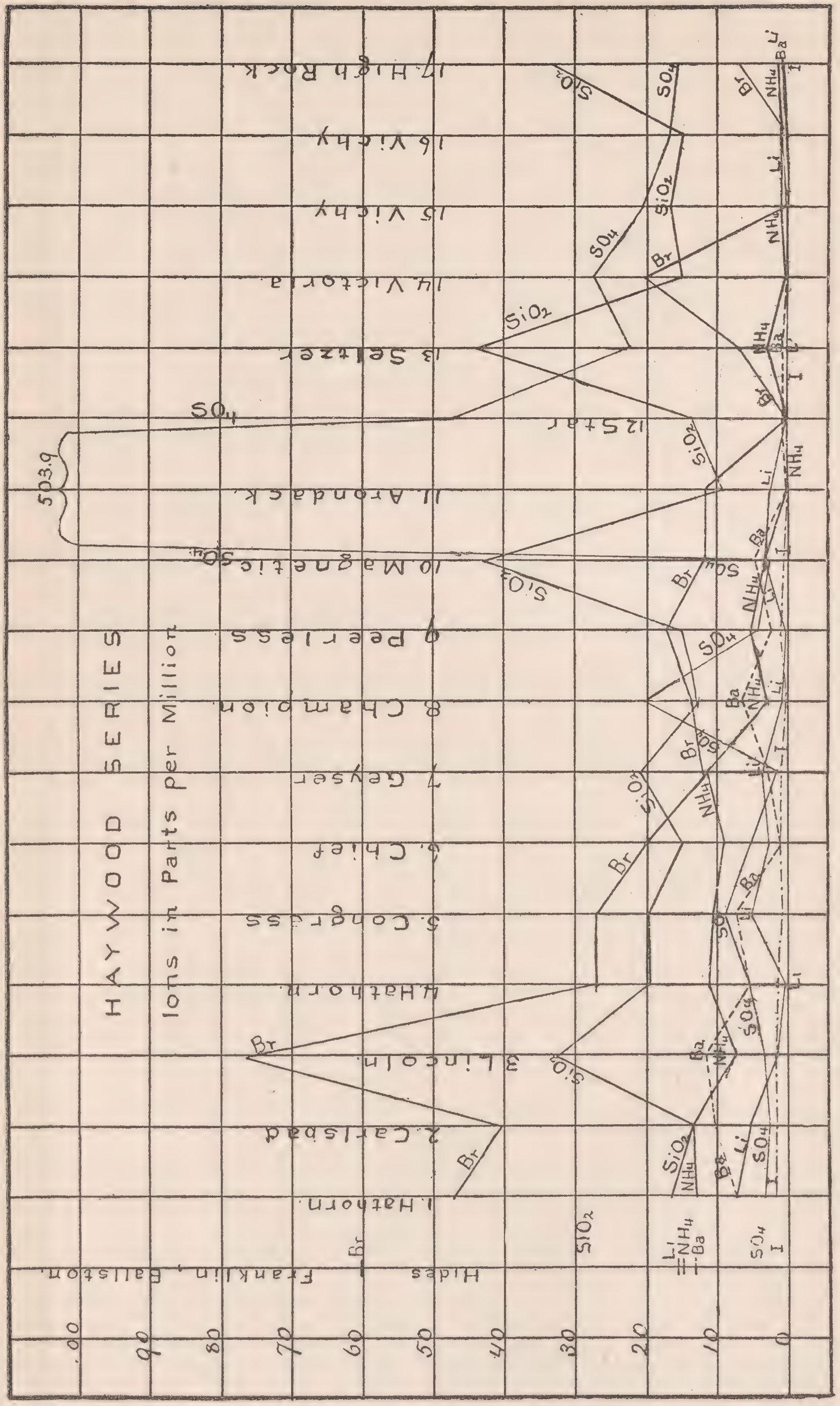

Figure 8 Diagrams of ions of the less abundant components, based on the analyses of J. K. Haywood and B. H. Smith 1905

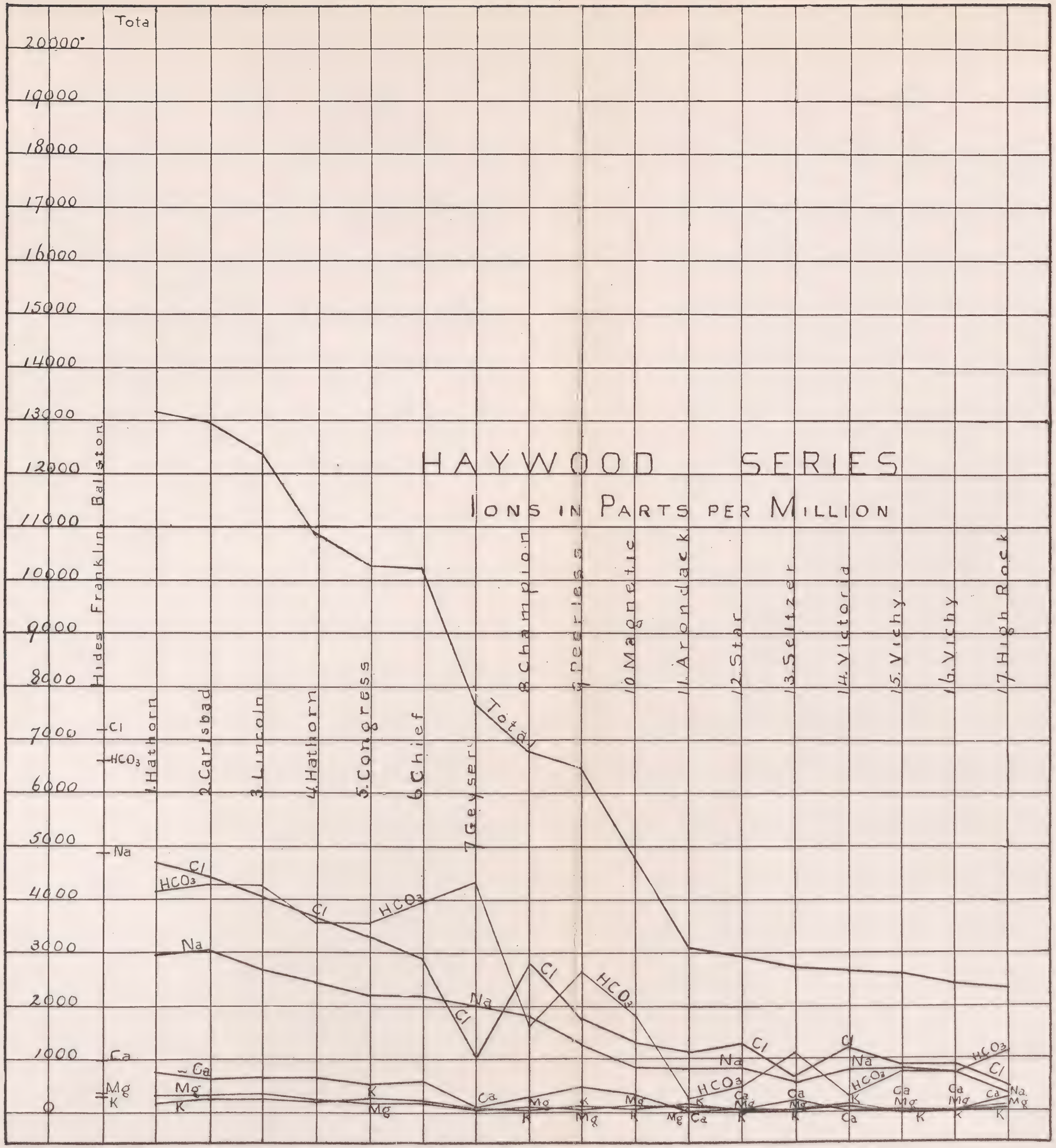

Figure 7 Diagrams of ions based on the analyses of J. K. Haywood and B. H. Smith

the northern part of the village. As the strength in salt and the total grains per gallon have diminished in later years, the relative amount of calcium bicarbonate has increased. This salt is always available for the carbonated waters to dissolve from the limestone. One would anticipate the same relation for the magnesium bicarbonate but in the high percentages of the table, it seems difficult to establish them. The magnesium salt is generally less than the lime, but in the six percentages of 20 and above, five exceed the lime salt, and one of the Congress' 1843, is almost equal.

In the values of $NaHCO_3$ above the superior limit of the general range, there are six, respectively: 22.4, 22.9, 25.2, 29.1, 33.0, and 67.3. All the other fifty-seven analyses (in three $NaHCO_3$ is not reported) run less than 15; forty-seven of them less than 10. The high values may be regarded in a questioning spirit.

In ten analyses no KCl is reported. Fifty-two others are less than 5. The three remaining are 6.8, 9.8 and 11.2.

These analyses are of interest when compared with those recorded for sea water on a subsequent page.

THE CARBON DIOXID

This gas is one of the most important features of the waters and is what gives them their palatable taste. Before undertaking its discussion a few fundamental properties of it may be recorded in order to make the subsequent statements intelligible. We have to distinguish between the uncombined (free) carbon dioxid and the portion combined with the bases as bicarbonates.

The combined portion remains in solution and is not apparent to general observation. The uncombined is also in solution in the depths of the earth, having formed with water, H_2O, carbonic acid, H_2CO_3, but as the water rises to the surface, this weak acid under the influence of diminishing pressures breaks up again into H_2O and CO_2. The gas escaping causes the effervescence or ebullition, as the case may be. Not all of it escapes because under the ordinary surface conditions the water retains in solution an amount of gas equivalent to its volume. That is, the water dissolves one volume of the gas. While the presence of the NaCl has some effect on the solubility of the CO_2, yet it is not enough seriously to influence the relations. The one volume of the gas which normally remains in solution can be driven off by boiling, or can be freed in a vacuum.

Ten cubic feet of CO_2, at ordinary temperatures and pressures, weigh practically one pound, so that one cubic foot is about .1 of a pound. If the specific gravity of air be taken as 1.0, CO_2 is 1.529. A liter of air weighs 1.293 grams, and a liter of CO_2 weighs 1.976. Gases are of course very sensitive to changes of temperature and pressure, and therefore in very accurate statements both have to be mentioned, but without going into too great refinements the above figures will answer for ordinary temperatures and pressures.

Since a gallon is 231 cubic inches, or .1337 of a cubic foot, a gallon of CO_2 weighs .01337 pounds or, as there are 7000 grains in a pound, about 93.6 grains. Where analyses are expressed in grains per gallon, and CO_2 is reported (as in the Chandler series) both as total CO_2, and as CO_2 in carbonates and bicarbonates, we can easily obtain the free gas by subtracting the latter from the former. If we then divide the free CO_2 expressed in grains by 93.6 we change it over to volumes. The necessary data are given in the Chandler series. In the analyses from the Department of Agriculture, the data are given in the thirteen analyses of samples taken directly at the springs. Since they are expressed in cubic centimeters per liter they read off directly in volumes, but it is obvious from the figures .that they do not represent the total gas that reaches the surface with the waters.

The best guide to the amount of carbonic acid gas emerging with the mineral waters is furnished by the experience of the gas companies. The richest in gas was found to be the Adams well of the New York Company now the General Carbonic Company. It yielded five volumes of the gas leaving one volume in solution. The general average, however, was two or three.

THE WATER SEAL

Under the general topic of carbonic acid gas, note may be made of a very curious phenomenon connected with the natural flowing springs which have been drilled and cased. If even in the most gaseous one the top of the casing be covered tightly so as to prevent the escape of the water and gas, and if the tight cover be maintained in this condition long enough to permit all the free gas to rise and collect immediately beneath it so that the well becomes quiet, the well will not resume its flow on removing the obstruction. It must be artificially started with a pump. The phenomenon is called the *water seal,* since the spring is, as it were, sealed off by water.

The explanation lies in the following relationship of the solubility of carbonic acid gas to the pressure under which the water stands

at time of solution. Thus, when the temperature is 55° F. under a pressure of one atmosphere water dissolves about one volume of carbonic acid gas. With a higher temperature it dissolves less, and with a falling temperature more. Under a pressure of five atmospheres it will dissolve at 55° F. about five volumes. Now an atmosphere is roughly 14 pounds pressure to the square inch, and is equivalent to a head of about 32 feet of water. In a standing column of water as soon as we pass a depth of 160 feet the overlying liquid will exert a pressure of 5 atmospheres and can keep 5 volumes of gas quietly in solution. As we go deeper more and more gas can be dissolved with the increasing pressure. The waters in the bored wells usually come from a depth of about twice 160, and are but half saturated with gas for that depth. All the gas is in solution just as it is in a siphon of carbonic water. If, however, we get an upward flow started, so that the dissolved gas under diminishing pressure can escape from solution, it replaces a part of the heavier water with the lighter gas, and greatly reduces the specific gravity of the water column, and therefore diminishes the pressure resting on its base. The solubility is reduced, more gas escapes and a flow of gas and water results. When a barrier is interposed the free gas escapes and collects at the top. Equilibrium of solution and pressure is established and the water stands quietly in the tube. Nevertheless it seems surprising, when one views the agitated spouting and gurgling of the springs, to think that they can be brought to rest by so simple a means.

It also follows that when carbonic acid gas is once in solution and at depths where the pressure prevents saturation and escape, the gas will remain in solution indefinitely. It is no more remarkable that this carbonated solution should be contained in the strata of the earth for one or several geological periods, than that a solution of common salt or of any other salt should do the same.

The Saratoga and Ballston springs are, on the whole, the richest in carbonic acid of those known in this country.

THE TEMPERATURE OF THE WATERS

The waters come to the surface with temperatures that are in almost all cases between 50° and 54° F. or 10°–12° C. Doctor Chandler records in a total of eight cases six between 50 and 52, and two at 48 and 46. For the Ballston waters he gives two at 52 and one at 54. Many readings at the wells of the General Carbonic Co. fall in with the first general statement of 50° to 54° F. The

prevailing temperature is somewhat above the mean annual temperature for Saratoga Springs.

The temperatures are appreciably higher in the summer than in the colder season, undoubtedly from the effect of the admixture of surface waters which vary with the months of the year. Mr J. C. Minor, jr, has made the following observations upon the wells of the former New York Co., now the General Carbonic Company. All but the last two were pumped wells.

	April 24, 1909	June 7, 1909	August 15, 1909
Old Hurlbut Well	51.2 F.	52.3 F.	53.2 F.
No. 1 Well	50.3	51.8	56.8
[1] Hathorn No. 1	51.4	52.9	53.8
[1] Hathorn No. 2	51.0	52.5	53.6
Bridge	50.3	50.8	53.0
Hayes	51.2	52.1	53.2
Adams	48.2	49.8	50.5
[2]Carlsbad		50.7	51.4

THE SPECIFIC GRAVITY OF THE WATERS

Doctor Chandler records the specific gravity of nine of the Saratoga springs; they vary with the amount of dissolved solids ranging from a minimum of 1.0034 to a maximum of 1.012.[3] The Ballston waters which are specially rich in dissolved salts, range from 1.0125 to 1.0159.

CLASSIFICATION[4]

Mineral waters are necessarily classified upon the basis of their chemical composition. A grouping especially favored in America is the following. A thermal spring, as defined by A. C. Peale, is one whose temperature exceeds 70° F. The scheme below is Haywood's modification of Peale's original proposal:

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[1] These wells called Hathorn No. 1 and No. 2 are not to be confounded with the well-known spring in the village nor with the new flowing springs south of Geysers Station. The names are purely of local application.

[2] Now the Caesa.

[3] There is an obvious misprint in the tabulated analysis of 1.096 for 1.0096 under the Congress Water. Amer. Chemist, Dec. 1871, p. 203. It is repeated in Cairn's Quant. Analysis.

[4] This subject is well treated by A. C. Peale in "Mineral Waters of the United States," U. S. Geol. Survey, 14th Ann. Rep't.

With minor subdivisions much the same is also used by J. K. Haywood, in Bulletin 91, U. S. Dept. of Agriculture, from which the analyses have been taken and so often commented upon above. Peale's classification is based on recast salts, Haywood's on ions.

GROUP	CLASS	SUBCLASS	FURTHER DESCRIPTION	FURTHER DESCRIPTION
Thermal and Nonthermal	1 Alkaline	Carbonated or bicarbonated	Iodic	
		Borated	Lithic	
		Silicated	Potassic	
			Calcic	
			Magnesic	Nongaseous
	2 Alkaline-saline	Sulphated	Ferruginous	Carbon-dioxated
		Muriated		Sulfuretted
		Nitrated		Azotized
	3 Saline	Sulphated	Aluminic	Carburetted
		Muriated	Arsenic	Oxygenated
		Nitrated	Bromic	
			Iodic	
	4 Acid	Sulphated	Silicious	
		Muriated	Boric	

1 Alkaline waters are those which give an alkaline reaction and contain carbonic, bicarbonic, boric or silicic acid ions in predominating quantity among the acids.

2 Alkaline-saline waters constitute an intermediate group between 1 and 3. They yield an alkaline reaction. Either with or without the acid ions mentioned under 1, they have in predominance, sulfuric, muriatic or nitric ions.

3 Saline waters are those which have an alkaline or neutral reaction and contain sulfuric, muriatic or nitric acid ions in predominating quantity.

4 Acid waters yield an acid reaction and contain either sulfuric or muriatic ions in predominance.

In descriptions Mr Haywood suggests that the terms in the table beginning with those headed "class" be used so that the columns with slight modifications come in the following order: 1, 4 through aluminic, 3, 2, 4 from arsenic to the close, 5. The Hathorn spring Mr Haywood describes as a nonthermal, sodic, muriatic, alkaline-saline (lithic, bromic, iodic) carbon-dioxated water. Other springs at Saratoga vary somewhat from this description. In those with high calcium, we might have to introduce calcic after sodic; perhaps also magnesic. Not every water has enough lithium, bromin or iodin to justify the terms lithic, bromic, or iodic. In a few sodium chlorid is in such marked predominance as to throw them into the saline class. The questionable analysis of the Geyser water with its extraordinary sodium bicarbonate, would come under the first class of alkaline waters. We are safe in saying, however, that the Saratoga waters belong under the alkaline-saline, rarely the saline

classes. That they are all muriated and sodic. Some are calcic and magnesic, one or both. Some are lithic, bromic, iodic, one or several. Practically all of importance are carbondioxated.

VARIATIONS IN THE WATERS

In the course of the last seventy-five years there have been variations in the waters as shown by the analyses and by the experience of owners of springs. Even if we allow for differences in the accuracy of chemical methods, and of chemists themselves, throughout this long stretch, a solid substratum of sound inference remains. Several instances will be of interest, but it is not only important but necessary to understand the possible modifying factors.

In the early years of settlement and utilization all the springs issued from natural crevices in the rock, possibly, as in the case of the High Rock, coming to the actual surface through gravel, bog, calcareous tufa, etc. In order to protect and maintain the flow it soon became customary to sink a pit through the overlying loose materials to the bedrock, and cement tightly to the rock around the actual vent, a pyramidal or conical wooden tube, prolonged in a pipe, within which the mineral water reached the surface, undiluted by admixtures of surface waters, so far as these stood in the gravels etc.

As time went by wells were drilled into the rock, either to restore old and dying springs or else to develop new ones of which there might be no surface indications. If successful these bore holes would strike a productive crevice. If they were continued below it, without additional supplies, the hole might later be plugged below the productive point. Above the productive crevice, the hole would be cased by a larger pipe, fitted tightly into the bore hole with a gasket at its lower end. A smaller pipe having been introduced within the casing, it also had a gasket above the supply point. The waters thus rose in the inner pipe. The casing kept out the higher and of course weak ground waters, and maintained the strength of the deep-seated mineral spring. If, however, the casing should rust through as was the experience in seven years' service of one pipe in a well on the property of the New York Carbonic Gas Co., this protection would no longer be afforded and weakening of the waters might follow. There are also some unsuccessful holes in which casings may or may not be left, and down which surface waters are tapped by a relatively large inlet to the productive horizons. In one case, that of the Ainsworth well, a charge of explosive was set

off several hundred feet beneath the surface and of course it shattered the surrounding rock, in a way which might give greater ingress to mineral waters, but might also give the weak surface waters a more favorable entrance.

Where active pumping is carried on, as has been the case on the properties of the gas companies, the ordinary level of the ground water is lowered near the pump or pumps and its surface forms an inverted cone, or approximation to a cone, called the cone of depression. The diameter of its base, or the radius of influence of the pump, can be determined by observation if there are wells all about. This matter was carefully studied on the property of the General Carbonic Co., and it was found that the remotest depression of the ground water observed was less than 400 feet from the pumps. The influence was irregular, some wells even quite near each other showed slight sympathy.

Where the wells have been drilled through slate in order to tap the productive limestone it is important to keep the casing tight because the slates furnish a water containing sulfur compounds, more particularly sulfuretted hydrogen, which even in small quantities gives an undesirable taste to the water. The inlet of surface waters from the slates is thus not only weakening to the spring but a detriment in other respects.

In the history of a water and in comparisons, it is unavoidable that samples should sometimes be taken from different vents on the same property. Thus, when older springs have given out, or perhaps have been obstructed with sediment, or have found other natural vents, new bore holes have been put down. But they are so near the old spring, as a rule, as to give presumptive evidence of tapping at least much the same underground source.

Parts per million

	J. H. Steel Before 1838	J. R. Chilton 1843	J. F. Dana ?	C. F. Chandler 1871	J. K. Haywood 1903–05
1 Congress spring					
Total	11197.9	11215.4	12324.3	11915.3	10232.7
NaCl	6545.0	6185.1	7384.8	6806.8	5141.6
$Ca(HCO_3)_2$	2701.3	2371.5	3966.1[a]	2437.8	2276.5
$Mg(HCO_3)_2$	1628.6	2325.6	544.0	2069.9	1674.9

a Undoubtedly the separation of calcium and magnesium was incomplete, some magnesium being weighed as calcium.

	J. H. Steel Before 1838		C. F. Chandler 1871	J. K. Haywood 1903–05
2 High Rock spring				
Total	6604.5		10718.5	2347.2
NaCl	3214.7		6631.7	738.2
$Ca(HCO_3)_2$	1907.4		2239.6	906.8
$Mg(HCO_3)_2$	1047.2		933.6	364.9
		E. Emmons		
4 Star spring		1839		
Total		6244.1	10495.1	2958.0
MaCl		3179.0	6772.1	2150.5
$Ca(HCO_3)_2$		71.4	2115.8	481.9
$Mg(HCO_3)_2$		2218.5	1052.4	130.8
	J. R. Chilton			
3 Pavilion	1840			
Total	6613.7		11583.5	
NaCl	3190.9		7818.3	
$Ca(HCO_3)_2$	1455.2		2042.9	
$Mg(HCO_3)_2$	168.3		1304.4	
2 Geyser				
Total			16856.3	7656.0[a]
NaCl			9555.7	1588.8
$Ca(HCO_3)_2$			2896.8	471.4
$Mg(HCO_3)_2$			2538.8	364.9
3 Hathorn				
Total	15102.8	13170.0	10859.0	
NaCl	8668.3	7343.7	5762.4	
$Ca(HCO_3)_2$	2901.0	3098.3	2635.3	
$Mg(HCO_3)_2$	2999.8	1974.7	1377.8	

	C. F. Chandler		J. K. Haywood
5 Seltzer	1869		1903–05
Total	5134.2		2737.0
NaCl	2283.1		1111.0
$Ca(HCO_3)_2$	1527.8		1000.0
$Mg(HCO_3)_2$	685.8		405.6
6 Vichy	1872		
Total	6244.5	2629.1[b]	2441.0[b]
NaCl	2187.9	1499.1	1459.5
$Ca(HCO_3)_2$	1623.8	158.8	167.3
$Mg(HCO_3)_2$	705.5	60.8	58.8

a This is the analysis with 5058.3 $NaHCO_3$.

b These two analyses have respectively 837.1 and 693.1 $NaHCO_3$.

	Sharples	J. K. Haywood
4 Kissingen, now the Arondack	1872	1903–05
Total	10958.7	3094.0
NaCl	5754.5	1725.1
$Ca(HCO_3)_2$	2384.4	104.1
$Mg(HCO_3)_2$	1198.0	236.2

	C. F. Chandler[a]	
1 Champion	1871	
Total	20324.9	6790.2
NaCl	11938.1	4521.6
$Ca(HCO_3)_2$	3860.2	1410.6
$Mg(HCO_3)_2$	3286.5	488.3

Ballston Spa

	C. F. Chandler	Dep't of Agriculture Later
Franklin Artesian well (now Hide's Franklin spring)	1869	than 1905
Total	20134.8	20542.6
NaCl	11208.8	11186.7
$Ca(HCO_3)_2$	3439.6	4007.2
$Mg(HCO_3)_2$	3023.7	2822.0

Study of these data brings out the following conclusions. The Congress spring shows no appreciable change from 1840 to 1870. From 1870 to 1903 it fell off about one-sixth or 12 to 13 per cent. The High Rock increased in strength from 1840 to 1870, presumably because of the prevention of inflowing surface water. It then fell off from 1870 to 1902 nearly 80 per cent in dissolved solids, most of all in NaCl. The Pavilion spring greatly increased in strength from 1840 to 1870, probably from improved protection against surface waters. The Star spring improved from 1839 to 1870, but then fell off from 1871 to 1903 over 70 per cent in strength. The Champion spring (discovered 1871) decreased from 1871 to 1903 about 70 per cent in strength. The Geyser spring from 1870 to 1903 fell off about 55 per cent. The Hathorn (discovered 1868) decreased from 1870 to 1903 about one-third in strength. The Kissingen or Arondack, as now called (discovered 1872), declined from 1872 to 1903 about 70 per cent. The Seltzer (discovered in 1865) from 1869 to 1903 fell off somewhat less than 50 per cent and finally the Vichy (discovered 1872) declined about 60 per cent.

The general conclusion from the concurrent testimony of these

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a Quoted by A. C. Peale, Bul. 32, U. S. Geol. Surv. p. 38.

comparisons is that the mineral waters, especially in Saratoga Springs village, have greatly declined in strength in the last thirty years.

By way of contrast two analyses are given of the Franklin Artesian water of Ballston Spa (discovered 1867), one made in 1869 and the other at least 35 years later in the Department of Agriculture, Washington. There is no appreciable change. The water comes from much greater depth than the Saratoga wells and far fewer wells have been drilled in Ballston.

THE ORIGIN OF THE MINERAL WATERS

The previous pages place before a reader the geological and chemical facts about the springs upon which, aided by experience gained elsewhere, the scientific explanations of their origin must be based. This interesting question did not fail to attract the attention of early observers. Dr J. H. Steel, to whom we owe so much of valuable record, was alive to the difficulties of the problem. On page 202 of the second edition (1838) of his book which was first published in 1817, he states in closing: "Much interest has been excited on the subject of the source of these singular and interesting waters, but no researches have as yet satisfactorily unfolded the mystery. The large proportion of common salt found among their constituent properties may be accounted for without much difficulty, all the salt springs of Europe as well as those of America being found in geological situations exactly corresponding to these,[1] but the production of the unexampled quantity of carbonic acid gas, and the medium through which the other articles are principally retained in solution, is yet and probably will remain a subject of mere speculation. The low and regular temperature of the water seems to forbid the idea that it is the effect of subterranean heat, as many have supposed, and the total absence of any *mineral acid* excepting the marine[2] which is combined with soda, does away with the possibility of its being the effect of any combination of that kind. Its production is therefore truly unaccountable."

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[1] Our more complete geological knowledge today would hardly justify us in admitting this sweeping statement.

[2] There are now known small amounts of sulfuric and nitric, but in the large way Doctor Steel's statement is true. It is reported that Doctor Steel was instrumental in organizing a company (in the decade of the twenties) to bore for salt deposits on the evidence of the springs, but that after drilling 110 feet the enterprise was abandoned.

Both W. W. Mather and L. C. Beck in their respective final State geological reports in 1842, discuss the springs but neither of them connects them with the fault which became later the object of much respect. In fact, while the cliff of limestone east of the springs is mentioned by Professor Mather in describing the valley in which the springs are found, he does not interpret it as a fault. On page 94 of the Report on the First District, Mather speaks as follows:

The Saratoga Springs are supposed to derive their mineral qualities from the limestone and slate beds that underlie the town, or they may be more deeply seated; but the water is usually obtained from beneath the clay and "hardpan" beds that overlie the rock. Limestone rock that belongs to the calciferous group, crops out in the village and in many places in the vicinity, and the primary rocks are not far distant on the north and west.

Regarding Ballston, he expresses himself as follows, on page 98: "It is probable that the mineral qualities of the water originate at the contact of the fucoidal slate with the underlying Trenton limestone, which is probably not more than fifty feet below the level of the valley at the springs." He then cautiously advises boring at some low point until the limestone is struck and that the hole be continued even to the calciferous sandrock. "At Saratoga the course of the water is supposed to be in the limestone, and this limestone which is the lower portion of the Mohawk, or upper part of the calciferous sandstone, must lie at a depth of one hundred and fifty feet at Ballston. Borings, however, might entirely miss a seam productive of water." It is interesting to note that the wells which have been bored go down through about four times as much slate as was anticipated.

Doctor Beck in his valuable report on the mineralogy of the State, discusses the chemistry of the waters at some length and gives several of the analyses which have been used on an earlier page of this paper. On page 137, after speaking of the discharge of gas at Saratoga and at Ballston, sometimes explosively at the latter, he states: "From these facts, it is evident that here, as at Saratoga, there are certain agencies in operation which cause an abundant evolution of carbonic acid, a part of which has been originally held in solution by the water but another and perhaps much the largest part is an independent stream of gas, discharged in the form of a solfatara, or gaseous spring. That this gas originates at great depths and rises freely through the crevices in the rock, is rendered probable from its alternately breaking and disappearing at points somewhat distant from each other. And perhaps the opinion of

Berthier may here be applied, viz, that the water of the spring is forced up by the elasticity of the confined gas. . . . In general, the occurrence of carbonic acid in these waters is to be ascribed to the existence of large quantities of it held in solution by water at great depths, and therefore under enormous pressure; or by the gas itself being kept by the same agency in a liquid form, until, by the removal of the pressure, it assumes the gaseous state, and is thus disengaged." These phenomena have been discussed in the light of modern chemistry and physics under the topic Water Seal, on page 40. At some date between 1842 and 1871, when Professor Chandler published the paper, to be shortly reviewed, the fault was recognized and was regarded as of importance in connection with the springs.

In the years just before and after 1860, Dr T. Sterry Hunt, chemist of the Geological Survey of Canada, published a number of papers dealing with the chemical side of geology and among them one of much importance in connection with mineral waters.[1] The paper has had a decided influence upon some of the current views regarding the Saratoga Springs, although Doctor Hunt refers to the springs only in a general way. Doctor Hunt's attention had been drawn to many waters which issue from the lower Paleozoic strata of Quebec and Ontario. He viewed these waters as representing the ancient Paleozoic sea in which the sediments had been deposited; that is, he believed them to be "connate" as the term has been explained on page 19. In a still earlier contribution read before the Geological Society of London,[2] Doctor Hunt states "When we examine the waters charged with saline matters which impregnate the great mass of calcareous strata constituting in Canada the base of the Paleozoic series, we find that only about one-half of the chlorine is combined with sodium; the remainder exists as chlorids of calcium and magnesium, the former predominating, while sulphates are present only in small amount. If now we compare this composition, which may be regarded as representing that of the Paleozoic sea, with that of the modern ocean, we find that the chlorid of calcium has been in great part replaced by common salt, a process involving the intervention of carbonate of soda and the

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[1] The Chemistry of Natural Waters. Amer. Jour. Sci. March, July, and September 1865. Reprinted with some omissions in Chemical and Geological Essays, 2d ed. p. 93–167, 1878.

[2] On some points in chemical geology, Quar. Jour. Geol. Soc. Nov. 1859. Chemical and Geological Essays, 2d ed. p. 10, 1878.

formation of carbonate of lime. The amount of magnesia in the sea, although diminished by the formation of dolomite and magnesite, is now many times greater than that of the lime; for as long as chlorid of calcium remains in the water, the magnesium salts are not precipitated by carbonate of soda."

Doctor Hunt believed that the bicarbonate of soda which entered the sea in river waters and which resulted from the decomposition of the soda-feldspars was the agent which had brought about this change in the long stretch of geological time since the early Paleozoic. Obviously, if Doctor Hunt's views are correct about the presence of calcium and magnesium chlorids in large proportions in the early Paleozoic sea water the Saratoga Springs are not derived from this ancient connate water, since calcium and magnesium chlorids fail.

On January 20, 1871, Professor Charles F. Chandler delivered a lecture on "Water" before the American Institute, at the Academy of Music, New York City. The lecture was published in December of the same year in the American Chemist, a monthly journal of chemistry, then in its second volume. The paper is an extremely valuable contribution and made public nearly all the analyses used in the "Chandler Series" of the preceding pages. Speaking of the origin of the springs, on pages 202 and 204, Doctor Chandler expresses himself as follows:

> The Laurentian rocks consisting of highly crystalline gneiss, granite and syenite, are almost impervious, while the overlying Potsdam sandstone is very porous and capable of holding large quantities of water. In this rock the mineral springs of Saratoga probably have their origin. The surface waters of the Laurentian hills, flowing down over the exposed edges of the Potsdam beds, penetrate the porous sandstones, become saturated with mineral matter, partly derived, perhaps, from the limestones above, and are forced to the surface at a lower level by hydrostatic pressure. The valley in which the springs all occur indicates the line of a fault or fracture in the rocky crust, the strata on the west side of which are hundreds of feet above the corresponding strata on the east.
>
> The mineral waters probably underlie the southern half of the entire county, many hundred feet below the surface; the accident of the fault determining their appearance as springs in the valley of Saratoga Springs, where by virtue of the greater elevation of their distant source they reach the surface through crevices in the rocks produced by the fracture.
>
> Their common origin is also shown by analysis. All the springs contain the same constituents in essentially the same order of abundance, they differ in the degree of concentration merely. Those from the deepest strata are the most concentrated. . . .

Then follow mention of the common dissolved substances and instances of the deep artificial borings which are believed to penetrate the Potsdam sandstone and which bring up waters much stronger than the natural springs. Doctor Chandler concludes this topic by saying: "Down in the rocky reservoir the water is charged with gases under great pressure. As the water is forced to the surface the pressure diminishes, and a portion of gas escapes with effervescence. The wells deliver, therefore, enormous volumes of gas with the water, a perfect suds of water, carbonic acid and carburetted hydrogen."

The above is a very clear and interesting statement of the views prevailing at the time regarding the waters. The important point of the source of the carbonic acid gas is not taken up, as perhaps could hardly be expected in a popular lecture, but even granting the suggested origin of the dissolved mineral matter from ancient sea water, there remains the very important matter of the gas which finds no explanation. More detailed geological study has furthermore reduced the throw of the fault in Saratoga Springs to about 50 feet and the water so far as we know in the springs under discussion all enters the bored wells from the Little Falls dolomite, or as it was called at the time Doctor Chandler wrote, the Calciferous sandrock, and later on the Beekmantown. The great depth of some of the boreholes is due to the thickness of overlying slate. The deep Hathorn drilled well did indeed at a depth of 1006 feet end well within the Potsdam sandstone, but the water coming from this source is stated to have been much weaker than that derived higher up, presumably from the Little Falls dolomite. The lower waters were plugged off, and so far as the writer is aware, they present the only case known to us of waters actually coming from the Potsdam in the region of Saratoga.

In September 1880, the American Pharmaceutical Association met in Saratoga Springs. One of its members, Mr Charles F. Fish, prepared an interesting sketch of the springs which, after presentation, was printed in volume 28 of the Association's transactions. On page 488 we find the following:

> One explanation is that the water falls on the western height of land and percolates downward artesian fashion, dissolving and carrying with it the various substances of which the rocks are composed. These are decomposed by their reaction on each other, forming new compounds with the evolution of CO_2, which is dissolved by the water, highly impregnating it, and increasing its solvent power. Reaching the fault, the waters rise.

The mineral matter resembles sea water and is supposed to be derived from ancient oceans.

Others, supporters of a second view, derive the waters as before, but reject the derivation of the waters' dissolved burden from the rocks. They think it reaches the fault relatively pure and then is charged with mineral and gaseous constituents, which have come up through the fault from the internal fires of the earth. The substances are those customarily given off by volcanoes.

In a valuable "History of Saratoga County" by Nathaniel Bartlett Sylvester, Esq., of the local bar, published in 1893, will be found on page 32, the following outline which summarizes very well the views held by many at this date regarding the springs:

The principal mineral springs of Saratoga county occur mostly in the villages of Saratoga Springs and Ballston Spa. The village of Saratoga Springs, where the greater number of the springs occur, is built directly over and extends for its whole length along on both sides of the dividing lines between the two great mountain systems above described, the Laurentian-Adirondack to the north and west, and the Appalachian to the east and south.

This dividing line between the two mountain systems, over and along which the village is built, is there characterized by a deep fissure or rift in the underlying strata, known to science as a fault. The fault was doubtless caused by the deep subsidence of the Appalachian strata along the division line, consequent upon the mighty upheaval to the eastward, when the mountains arose from the Silurian sea. This profound subsidence of the Appalachian strata along the division line sank the bottom waters of the Silurian sea, which covered the land with all of its accumulated marine riches, into a vast abyss which now underlies the village to the eastward of the rock fissure. Out of this reservoir of old marine treasures, the gases there engendered still force the waters, which bring these marine riches with them, up through the deep fissures in the rifted rocks into the light of day, thus forming the natural mineral springs of Saratoga, which rise to the earth's surface in Saratoga county.

Again, on page 160, the same view is repeated in briefer statement. Judge Sylvester's description in its quaint and precise legal phraseology makes clear the widespread view of recent years that the Silurian sea water had saturated the rocks and that it had remained in them ever since so as to now furnish the mineral waters. We are forced to modify our unqualified acceptance by recalling Dr T. S. Hunt's conclusion that these ancient waters had a radically different composition from that of the springs (see above, pages 50, 51). One can not but raise the question also, whether, inasmuch as the area has apparently been land, it may be, ever since Paleozoic time, the ancient sea waters could well have been preserved through-

out so long an interval. The fault, too, while a very long one, has only the slight disturbance of about 50 feet in Saratoga Springs.

If we are impressed with the possibilities of sea water in the rocks, and at first glance the generalities of composition suggest them, we may query if the ancient seas are the only source. The springs suggest rather the modern sea, with its high sodium chlorid, than the ancient ones with high magnesium chlorid, as described by Dr Sterry Hunt. Has the sea of fairly recent geological time ever covered the region of Saratoga?

We know from the rapidly growing number of buried river channels that the closing Tertiary period was a time of relative elevation in the northeast. The bedrock on which the water once flowed is now far below the present surface. The Glacial epoch apparently opened with elevated conditions but closed with a great depression of the land. Lake Champlain was certainly connected with the sea, as was shown by the skeleton of a whale, dug out of a sand bank in the town of Charlotte, Vt., when the Rutland and Burlington Railroad was under construction. The railroad runs through Charlotte at about 200 feet above tide, so that the sea water must have stood above this level. The present divide between Wood creek, the southern inlet of Lake Champlain, and the feeders of the Hudson near Dunham Basin, is a little over 160 feet. The post-glacial sea might so far as we can see have crossed from Lake Champlain to the Hudson, but whether it stood as high as the 300 or 320 feet contours on which the springs emerge is not demonstrated, although not improbable. If the sea had stood above these strata, they being presumably filled with earlier fresh ground water, we may wonder if it could have found a way to fill their interstices, and drive out the fresh water. Sea water is heavier than fresh, and having access to the underground reservoirs of fresh water would probably have at least diffused itself through them. We may therefore admit that possibly an arm of the Atlantic stood in post-glacial times above the present sites of the springs.

But the hypothesis of the sea water deserves very earnest attention. Our only safe ground is to run some careful comparisons between the mineral springs and the modern sea water, with perhaps some further reservations regarding possible differences between the oceans of today and those of the past.

Analyses of sea water have been prepared in the greatest abundance. Samples have been taken not alone from the ocean, but also from estuaries and arms which may be only brackish. Analyses are

sometimes published of the water and its dissolved salts and sometimes of only the evaporated residue. Results in the latter case may be expressed either in the form of salts or in that of elements and ions. Taking a collective statement of results from F. W. Clarke's "Data of Geochemistry," Bulletin 330 of the United States Geological Survey, we find on page 23, that the general salinity of the ocean is about 3.5 per cent or 35,000 parts in a million, whereas our strongest Saratoga or Ballston waters fail to reach 2 per cent or 20,000 parts in a million, when we express the dissolved mineral matter as normal carbonates instead of bicarbonates. We may perhaps assume the admixture of surface waters as conceivably reducing the strength of the latter when compared with the former, or we may assume estuarine sea water, like that of the Baltic which is dilute. An average range for Saratoga Springs waters in former years was about 1 per cent or 10,000 parts in a million (see above, page 34) and from the most recent analyses we learn that a notable number lie between .2 and .3 per cent, or 2300 to 3100 parts per million. The latter values imply still greater admixtures of meteoric ground waters.

If the salts of the ocean are analyzed after evaporation to dryness, they yield a general composition as given by Dr F. W. Clarke (page 23) of

$NaCl$	77.76
$MgCl_2$	10.88
$MgSO_4$	4.74
$CaSO_4$	3.60
K_2SO_4	2.46
$MgBr_2$	.22
$CaCO_3$	.34
	100.00

Considered as elements no others would reach more than 0.001 per cent and are therefore negligible.

These results are obviously very different from the Saratoga and Ballston waters, in which, as has been shown on the previous pages, while we have NaCl as the chief ingredient, we yet have no $MgCl_2$, and almost no sulphates. The sea salts, on the contrary contain 10.80 per cent of the last named. In the oldest series of analyses of Saratoga waters (see above, page 24), the richest percentage in sulphates was .0028 and the poorest .0011. In the Chandler series the richest was 0.0091 and the poorest a trace. In the Department of Agriculture series the richest was 0.04449 per cent and the

poorest 0.00021 per cent. Stated in this way, there is a very obvious and important difference between the mineral waters and the sea waters.

But we may run comparisons in another way: Dr F. W. Clarke summarizes upon page 95 of his invaluable work 264 analyses from eighteen different localities, whose salinity varies from a maximum of 5.854 per cent in the Red sea, to a minimum of 0.7215 per cent in the Baltic, where, as the writer has personally observed, both people and animals freely drink the water. When expressed as elements and ions there is extraordinary uniformity in the dissolved salts of the sea despite the widely varying salinity:

	MAXIMUM	MINIMUM	RANGE
Cl	55.96	54.62	1.34
Br	.19	.13	.06
SO_4	8.01	7.47	.54
CO_3	.46	.01	.45
Na	31.21	30.20	1.01
K	2.10	.64	1.46
Rb	.04	.03	.01
Ca	1.67	.89	.78
Mg	3.896	3.36	.536
Fe, SiO_2, PO_4, NH_4, NO_3, Al_2O_3, (Fe_2O_3)	.08	.02	.06

The last mentioned ingredients which are collectively grouped are only determined in a few instances. The same is true of rubidium (Rb). The greatest variability is shown by CO_3 and the next by potassium (K), but their amounts are relatively small. Calcium (Ca) also varies widely, but it also is small in amount. The most important ingredients, taken in order of abundance, chlorin (Cl), sodium (Na), the sulfuric acid ion (SO_4), and magnesium (Mg), change but slightly in this wide range of conditions.

When we come to compare the analyses of the Saratoga and Ballston waters with the above, certain allowances must be made. The mineral waters are heavily charged with carbonic acid which gives them greatly increased dissolving power upon limestone. We would expect the calcium and perhaps also the magnesium to be much in excess of the percentage in sea water. In making comparisons we would be justified in tentatively assigning the excess of calcium and of carbon dioxid over the figures of sea water to contributions provided in this way, and then recasting the remainder. We must also deal with analyses that are based upon *bona fide* natural waters. I therefore select a few chiefly from the series of

Dr Charles F. Chandler, adding to them several of later date, in which I have confidence. It has been necessary to reduce grains per gallon, or parts per million, to percentages of evaporated residue. Water must therefore be thrown out, and as compared with analyses previously discussed bicarbonates become normal carbonates.

Normal calcium carbonate in pure water (that is, containing no free carbonic acid) is stated by F. W. Clarke on the authority of T. Schloesing, to be soluble at 16° C. to the extent of 13 parts in a million (U. S. Geol. Surv. Bul. 330, p. 99, 1908). Calcium bicarbonate, that is, calcium carbonate in water with enough free carbonic acid to yield the bicarbonate, is soluble 385 parts in a million at 15° C. (Idem, page 99). Excess of carbonic acid increases the solubility as is shown by the values just cited for the Saratoga waters, which are about ten times that just given for $Ca(HCO_3)_2$ in pure water. On the other hand, sea water is not so good a solvent as pure water, and the Saratoga waters, in so far as they are brines, probably are also less favorable solvents than are pure waters.

Magnesium carbonate is stated by J. Roth (Allgem. and Chem. Geologie, I, 50. 1879), to be somewhat more soluble in carbonated waters than is calcium carbonate. The presence of calcium carbonate doubtless exercised some influence since in the Saratoga waters, just as Professor Roth states for waters in general, it is exceptional to find more magnesium carbonate than calcium carbonate.

	FRANKLIN, BALLSTON	HATHORN, SARATOGA	CONGRESS, SARATOGA	SELTZER, SARATOGA	HATHORN NO. 2, GEYSERS	GURN, WILTON
Cl	42.00	42.40	42.00	34.40	41.20	28.10
Br	.36	.16	1.10	.20	.10	.16
SO_4	.04	tr.	.09	.13	.04	.....
CO_3	15.00	18.50	17.50	25.75	17.00	25.30
Na	28.8	27.30	27.60	25.50	30.80	26.00
K	2.0	.70	.80	.40	.48	2.33
Ca	5.0	5.70	6.00	9.30	6.22	11.20
Mg	5.0	4.00	3.40	2.80	3.07	3.40
Rest	1.80	1.24	1.51	1.60	1.09	3.51
	100.00	100.00	100.00	100.00	100.00	100.00

Of these analyses the first four are by Doctor Chandler. The fifth is of the recently bored well two miles south of Saratoga Springs and the analysis was made in the laboratory of the State Department of Health in 1911. The sixth is from the Lederle Labora-

tories, New York, and was made in 1910. It illustrates the most northerly of the present active springs, since the Gurn is eight miles from Saratoga Springs. The analysis brings out the tendency of the waters to the north to be richer in calcium, which in turn calls for more CO_3 and reduces the chlorin and sodium. The same effect is shown in the Seltzer water.

If in the above analyses we arbitrarily reduce the calcium to 1.67 as given in the sea water richest in this element, and the CO_3 to .46, as given in the sea water richest in this ion, thereby necessarily assuming the existence of calcium chlorid which no one has hitherto recalculated for the Saratoga waters, we can get a line on the ratio of sodium, chlorin, and magnesium. All this is done on the assumption that the high calcium is obtained from the limestone. Some magnesium is also undoubtedly obtained from the magnesium limestone, but the difference between the mineral waters and the sea water is not so great. In the recasting I have used the nearest round numbers. Thus, the analyses of the mineral waters have their several percentages respectively increased by dividing by approximately the following residual percentages: 82, 72, 79, 66⅔, 79 and 66⅔, left by abstracting the Ca and CO_3.

	SEA WATER	SEA WATER	FRANKLIN, BALLSTON	HATHORN, SARATOGA	CONGRESS, SARATOGA	SELTZER, SARATOGA	HATHORN NO. 2, GEYSERS	GURN, WILTON
Cl	55.12	55.01	51.20	54.36	53.17	52.60	52.00	43.23
Br	.18	.13	.44	.21	1.40	.30	.13	.24
SO_4	7.47	8.00	.05	tr.	.11	.20	.05	.....
CO_3	.46	.14	.46	.46	.46	.46	.46	.46
Na	30.46	30.47	35.12	35.00	35.00	37.55	40.00	40.00
K	1.16	.96	2.42	.90	1.00	.60	.61	3.74
Ca	1.41	1.67	1.67	1.67	1.67	1.67	1.67	1.67
Mg	3.74	3.53	6.10	5.13	4.30	4.20	4.00	5.23
Rest	....	.09	2.20	1.60	1.91	2.40	1.40	5.40
	100.00	100.00	99.66	99.33	99.02	99.98	100.32	99.97

The first analysis of sea water is the one having the maximum CO_3, and is an average of six from the Black sea. The salinity varied from 22,230 parts in a million to 18,260. The second analysis of sea water has the maximum Ca and is from the Baltic sea. The salinity was 7215 parts per million. In these statements the carbonates are all calculated as normal carbonates, and the salinity is reckoned on the evaporated residue. In the mineral waters, expressed in the same way, the salinity varies from 16,870 parts per

million for the Franklin well, and 16,283 for the Hathorn No. 2, to 4062 for the Seltzer.

Now when we critically compare these analyses we see that no mineral spring quite reaches the values in chlorin possessed by the sea water, but in four cases the approximation is very close. If we take away a little magnesium on the assumption that it was furnished by the limestones, the chlorin percentages for these four would be substantially like those of the sea water. So far as chlorin is concerned the parallel is close. On the other hand, the mineral waters are from 5 to 10 actual per cents richer in sodium and for this element no close parallel can be drawn. If we remove some magnesium for the reason just stated, the contrasts will be still further accentuated. In SO_4 the sea water is vastly richer, actually from 37 to hundreds of times as rich as the mineral waters. There is a fundamental difference here which can not be easily explained. The mineral waters are richer in bromine. They are uniformly richer in magnesium. They are both richer and poorer in potassium. On the whole, the lack of SO_4 in the mineral waters and its presence in the sea water as calcium and magnesium sulphate argues strongly against a marine source for the mineral waters. We can not imagine calcium and magnesium removed from connate sea water in any probable reaction in the earth, which would not yield other salts that also fail in the mineral waters. The notable excess of sodium can not easily be explained by a marine source, while the great richness in carbonic acid gas can only be referred to a source in the depths of the earth, probably from some expiring center of igneous activity. The writer is therefore led to the conclusion that both gas and dissolved mineral matter are derived from deep-seated sources.

There is an additional and apparently irrefutable argument. We have in a great many places in the Champlain and Hudson valleys practically the same geological section with the exception that it changes on the north because of the addition of the Chazy limestone. The section is frequently broken across by faults of vastly greater displacement than the one at Saratoga Springs; yet even uncarbonated brine springs are lacking.

If the Saratoga and Ballston springs derive their mineral matter from ancient sea water contained in the local strata, it is extraordinary that we have not abundant brine springs, even if not carbonated, in many localities to the north and south. So extraordinary is it that we are logically forced to abandon the explanation.

We may now direct special attention to the carbonic acid gas. There are four ways in which carbonic acid is produced in nature.[1] The simplest is by the direct oxidation of carbonaceous deposits, such as peat bogs, coal seams, and the like. It is one of the dangerous gases in coal mines, constituting the choke damp of the miner. We have no reason to believe, however, in the existence of carbonaceous beds of this sort beneath Saratoga and much reason to infer their absence. The second method is by the action of some free acid such as sulfuric upon limestone. Sulfuric acid is sometimes produced in nature by the oxidation of pyrites, in the presence of water. If it meets with limestone it destroys the carbonate of lime, evolving carbonic acid gas and forming calcium sulphate. Since hydrated calcium sulphate is the mineral gypsum, gypsum beds have been sometimes explained in this way. We have no reason to infer gypsum beds beneath Saratoga, nor do we find in the waters the calcium sulphate which would be demanded by this reaction. We may dismiss this explanation also.

The third method of formation is by the silicification of limestone. Silicic acid in solution, especially around the borders of still heated masses of igneous rock, displaces the carbonic acid of calcium carbonate and forms calcium silicates. The carbonic acid then migrates. It is possible that some such process as this deep down in the Grenville strata either has taken place or is taking place and that the gas thus liberated is still rising to the surface or has risen and now remains in solution in the waters.

The last and most important explanation of free carbonic acid as it is met in foreign localities, is based on expiring volcanic or igneous action. It is a matter of observation that the copious emission of the gas is one of the characteristic features of volcanoes which are no longer active. As time passes the zone of gas emission appears to widen around them until it finally ceases. The amount furnished is in instances prodigious. One borehole at Sondra in Thuringia, Germany, 197 meters deep, yields daily at a pressure of about 230 pounds to the inch, over 500,000 kilos, or over 1,000,000 pounds of the gas. At another place, Oberlandstein, 6,000,000 litres in 24 hours are obtained, or 20,000 pounds of the gas.[2] The utilization of the gas is the basis of an important industry in Germany and supports a special journal.

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[1] An excellent general summary of the geology of carbonic acid gas is a paper by Rudolph Delkeskamp, Vadose and Juvenile Kohlensäure. Zeitschrift f. prakt. Geologie, Feb. 6, 1906, p. 33.

[2] N. Wender. Die Kohlensäure-industrie, Berlin, 1901, p. 72–73.

We are not definitely assured as to the reaction which produces the gas deep within the earth. Whether it is emitted directly from cooling masses of igneous rock, as is not unreasonable from some things that we know about them, or whether it results from the action of the igneous rock on limestone, perhaps through the intermediation of silicic acid, as was explained in an earlier paragraph, may be a matter of uncertainty.

If we endeavor to apply these views to the specific case of Saratoga, we are reminded of the volcanic plug discovered at Northumberland, on the west bank of the Hudson, about ten miles a little north of west from the springs in the village.[1] The plug is so isolated from all others of its kind and positive evidence of its age is so difficult to obtain, that its time of outbreak is very obscure. Since first studied ten years ago by Professors Woodworth and Cushing, it has been nearly half quarried away for macadam and concrete and its structure and features are much better exposed. If anything they have made it more difficult to understand. The complexity of the stratigraphical relations of the vicinity has been increased by Doctor Ruedemann's discovery of late Cambrian fossils in the slates. These matters will be fully discussed by Professor Cushing in the Bulletin on the Saratoga Quadrangle. The writer has had the privilege of visiting the plug with Professor Cushing and Doctor Ruedemann and of discussing the question at length. That the mass is volcanic seems to me the best explanation, and that it is an elliptical agglomerate representing an old vent and formed of bombs and masses of limestone torn off from the walls of the throat down below, I feel convinced. The excessive alteration argues for an outbreak which probably antedates the Tertiary period, but to what extent I can not say. The plug is so far as known the only purely volcanic rock within the confines of New York, Vermont, or of Massachusetts west of the Connecticut valley.

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[1] The plug was first recognized by J. B. Woodworth in the summer of 1901. It was carefully studied by him and described in the 21st Report of the N. Y. State Geologist, p. r 17–r 24. The petrography was contributed by H. P. Cushing, p. r 24–r 29. Professor Woodworth remarks the similarity with the Triassic traps of the Connecticut valley; and Professor Cushing very cautiously suggests the parallels between the plug and the same occurrences and those of the lower Hudson (i. e. the Palisades) and New Jersey. A Triassic age seemed the best suggestion for a confessedly obscure and uncertain occurrence.

No one could with much reason attribute the carbonic acid gas to the Northumberland plug itself, but the plug does serve to show the former existence of volcanic action and unless it has been thrust westward into its present position by some great reversed fault from an original situation farther east, as will be outlined by Professor Cushing, it may be considered significant to this extent. We may at least state that all the other geological features of Saratoga Springs and Ballston Spa are reproduced in many places northward throughout the Champlain valley. Practically the same geological section is seen. A great number of faults have been mapped and yet no such mineral springs have ever been discovered. The great quantities of carbonic acid gas in the water are distinctive of the two localities, Saratoga Springs and Ballston. The only other visible and distinctive feature of the Saratoga region as compared with the localities farther north is the volcanic plug. One may merely suggest the possibility of some more westerly and deep-seated manifestation of the same sort of activity through whose influence the carbonic acid gas rises through faults to the surface. The tight cover of slates east of the fault may have kept from emergence at the surface the waters in which the gas speedily became dissolved.

Even sodium chlorid itself has been attributed to volcanic sources. Thus Sir Archibald Geikie, in his Text-book of Geology, 4th ed. 1903, I, p. 269, when speaking of volcanic emissions, states: "Sodium chlorid sometimes appears so abundantly that wide spaces of a volcanic cone, as well as of the newly erupted lava, are crusted with salt which can be profitably removed by the inhabitants of the district. Considerable quantities of chlorids may be buried between successive sheets of lava, and in long subsequent times may give rise to mineral springs, as has been suggested with reference to the saline waters, which issue from volcanic rocks of old Red Sandstone and Triassic age in Scotland." Again, on page 469, we find: "Carbonic acid is here and there largely evolved within the earth's crust, especially in the regions of extinct or dormant volcanoes. Subterranean water coming in the way of this gas dissolves it and thereby obtains increased solvent power." Professor L. De Launay of Paris, in a very important work[1] upon the Investigation, Discovery and Management of Mineral Springs, under the caption

[1] L. De Launay, Recherche, Captage et Aménagement des Sources Thermo-Minerales, Paris, Banday et Cie, 1899.

Carbonated Springs, Origin of the Free Carbonic Acid, page 130, speaks thus of carbonic acid gas, the original French being here rendered into English:

When we examine the map of an entire country, whereon the mineral springs have been each indicated by a special sign, corresponding to their chemical composition, we soon see a general fact stand out, which could escape us in too detailed study or remain open to question, but which in a comprehensive survey is perfectly plain; it is the almost absolute restriction of springs with free carbonic acid to the regions of Tertiary or recent volcanic activity, such as the Auvergne, Bohemia, the Carpathians, the Apennines, etc.

In a discussion regarding the source of the waters of the Saratoga springs which was held in New York at a meeting of the National Academy of Sciences in November 1911, Mr Waldemar Lindgren raised the point that bromine was present in the waters but that so far as he was aware it had not been reported in volcanic emissions. It is, however, a well-known ingredient of the sea waters. On looking the matter up the writer realizes that bromine is far less abundant than chlorine, probably also less abundant than fluorine and iodine in the volcanic gases, and that it has not been so generally mentioned. Matteucci, however, in reporting upon the Vesuvian eruption of 1895, mentions hydrobromic acid as one of the fumarolic products.[1] It would be surprising if amid the very great quantity of chlorine, its other closely related haloids, bromine, fluorine and iodine were not all present in minor amounts. Both hydrofluoric and hydriodic acids were also observed by Mateucci. Fluorine and iodine have been more often reported than bromine which is, at best, a comparatively rare element.

In addition to the sodium chlorid just cited as a well-known volcanic exhalation, potassium and ammonium chlorid are also cited in the works which give analyses of these products. Sodium carbonate also forms by secondary reactions and in fact practically all the ingredients of the Saratoga mineral waters are reported, except those such as calcium, magnesium, barium, strontium, and iron carbonates, which would be easily dissolved from the limestones by circulating carbonated waters; alumina, iron oxids and silica which might come from these or other rocks through the medium of the same solvent.

The explanation which appeals most strongly to the writer is that the carbonic acid gas, the chlorids, bromids, iodids, fluorids, and

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[1] Comptes rendus, 129, 65, 1899.

sodium carbonate are deep-seated. The sodium carbonate might in part or in whole be dissolved from the feldspars in the old crystalline rocks. The carbonated waters take on calcium and magnesium carbonates from the limestones encountered in their upward journey, more especially from the Little Falls dolomite. They mingle with artesian waters from the west, which may furnish a good portion of the motive power toward the close of the ascent. Their greatest vents lie in or near the fault, which passes through Saratoga Springs, but not all are demonstrably on it. The Gurn spring is near a branch. The course of the fault is less clear at the Geysers, at Ballston and at Round Lake, but if not the same, then some other fault is probably present. For the old Albany well a similar explanation is suggested. The faults furnish the upward passages of the gas and dissolved mineral matter from the depths, but the tight cap of slates above the limestones acts as a roof to prevent their escape, except in the springs and bore holes. The source of the mineral matter and the gas is probably east of Saratoga Springs and Ballston.

TABLE 1

Analyses by Dr John H. Steel, 1817 and earlier. Grains per gallon of 231 cubic inches

	CONGRESS	COLUMBIAN	WASHINGTON	HAMILTON	FLAT ROCK	HIGH ROCK	PRESIDENT	RED	TAYLOR'S WASHINGTON	TAYLOR'S JACKSON	TAYLOR'S ALEXANDER	ELLIS'S	SULFUR	BALLSTON VILLAGE	BALLSTON LOWS	BALLSTON SULFUR
Muriate of soda	471.5	201.5	231.5	269.5	194.8	210	135	117.58	313.54	240	238.4	188	23.6	159	142	64
Carbonate of lime	178.476	121	127.5	147.5	107.0	115	107.5	97	140	103.8	119.5	110.5	33.1	75.5	64.5	30
Carbonate of soda	16.5	22.5	16.5	24.5	11.2	18	19	24.48	26.46	18	19.6	10	1.4	9	10	6
Carbonate of magnesia.	3.356	1.5	2.5	7.9	1.5	.5	2.5	3	5.5	3	7	.....	.....	2.5	1.5	.....
Carbonate of iron	6.168	7.5	6	3.0	7.5	4.5	6	6	4.1	5.2	5.5	7.5	1.9	7	6	4
Total	676	354	384	452	322	348	270	248	489.6	370	390	316	60	253	224	104
Carbonic acid gas, cu. in	343	236	247	284	252.5	243	314	150.5	251	256.5	253	224.5	43.5	210	220	144
Temperature	50° F.	50° F.	48° F.	48° F.	48° F.	48° F.	51° F.	48° F.	48° F.	50° F.	48° F.	47° F.	50° F.	50° F.	52° F.	52° F.
Sulfuretted hydrogen, cubic inches	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	11	.....	.....	7

NOTES. All the analyses are taken from "An Analysis of the Mineral Waters of Saratoga and Ballston, etc.," by Dr John H. Steel. Albany. E. & E Hosford, 1817. The Columbian spring was about 15 rods west of the Congress. The Washington was about 50 rods southwest of the Columbian. The Hamilton was about 50 rods northeast of the Congress and was in a marsh. The Flat Rock was about 100 rods down stream from the Hamilton. The High Rock was about 100 rods north of the Hamilton. The President was about 30 rods from the High Rock (presumably north), and in the same valley. The Red spring was northeast of the President, the distance not being given. Taylor's springs were about one mile east of the High Rock and were apparently the same as the Ten springs of today. Three of them were named Washington, Jackson and Alexander. Ellis's spring was about two miles south of the Congress, in a deep valley of the principal northern branch of Kayaderosseras creek. It was obviously near the Geysers and the valley of Coesa creek. The Sulphur spring was two or three miles up Coesa creek from Ellis's spring. The first Ballston analysis was of a spring near the center of the village. Low's spring was about 100 rods down stream. The Ballston Sulphur was twenty feet from the last named.

TABLE 2

Analyses by Dr John H. Steel, 1817–1825, and 1825–1837. Grains per gallon of 231 cubic inches

	WALTON	BALLSTON NEW SPRING	BALLSTON LOW TUBE		CONGRESS	COLUMBIAN	WASHINGTON	HAMILTON	FLAT ROCK	HIGH ROCK	BALLSTON SANS SOUCI	BALLSTON NEW WASHINGTON
Muriate of soda.....	274.8	145.0	158.5	Chlorid of sodium.....	385.0	267	281.5	297.3	148.816	189.10	143.733	89.83
Carbonate of soda....	5.2	12.0	13.0	Hydriodate of soda.....	3.5	2.56	2.75	3.0	1.33	2.5	1.3	0.7
Carbonate of lime....	140.0	61.5	61.54	Bicarbonate of soda.....	8.982	15.40	16.5	27.036	20.79	17.538	12.66	18.057
Carbonate of magnesia	7.0	9.0	8.5	Bicarbonate of magnesia..	95.788	46.71	40.92	35.2	42.70	61.592	39.10	42.042
Carbonate of iron....	7.5	7.5	7.5	Carbonate of lime.....	98.098	68.00	92.60	92.4	60.573	69.29	43.407	41.51
Silex.....	Small quan.	tr.	tr.	Carbonate of iron.....	5.075	5.58	3.25	5.39	5.39	5.58	5.95	3.71
Alumina.....	" "	tr.	tr.	Silex.....	1.5	2.05	1.50	.....	tr.	tr.	1.0	1.25
					tr.	tr.?	.....	tr.	tr.	tr.	.....	.....
Total.....	434.5	235.0	249.04	Hydrobromate of potash..								
Carbonic acid gas....	Abundant	Abundant	Abundant	Total.....	597.943	407.30	439.02	460.326	279.649	345.68	247.15	197.099
Temperature.....	47° F.	50° F.	50° F.	Carbonic acid gas, cu. in..	311	272.06	262.5	316	287.5	304		
				Atmospheric air, cu. in...	7	4.5	6.8	4	6.5	5		

NOTES. The analyses of the previous table together with the first three given on this table appear in the second edition of Doctor Steel's book, published in Saratoga Springs in 1825. The Walton spring was a few rods from the Flat Rock. The New spring of Ballston was uncovered by a freshet in 1817. It was some rods below the Village spring of the previous table. The Low Tube is apparently the Low spring of the earlier edition. The last eight analyses are from a later edition of Doctor Steel's book, published in 1838, just after his death. The determinations were all made anew. He also gives notes but no analyses of the President, Red, Ten springs, and Ellis'. He speaks of the Quaker springs, 10 miles southeast of Saratoga, as containing lime, magnesia, iron and a certain percentage of common salt and soda. The gaseous contents were small. At Ballston the Sans Souci was near Low's spring. The Park spring is credited with 5 grains of carbonate of iron. The New Washington had a spec. gr. of 1.0046. Temperature 51° F.

TABLE 3

Various early analyses. All stated in grains per gallon of 231 cubic inches

	1 CONGRESS	2 CONGRESS	3 CONGRESS	4 UNITED STATES	5 EMPIRE	6 PAVILION	7 ALBANY	8 ALBANY	9 PUTNAM	10 RED	11 UNION	12 WALTON	13 WASHINGTON	14 COLUMBIAN
Chlorid of sodium	434.4	385.44	363.83	424.96	269.70	187.68	504.00	472.00	214.00	83.53	243.62	187.00	182.00	267.00
Carbonate of soda	16.0	.56	7.20	16.88	30.85	4.92	40 00	40.00	14.32[a]	15.33[a]	12.80	2.00	8.00[a]	15.4[a]
Carbonate of magnesia	32.0	56.80	78.62	5.76	41.98[a]	56.92	16.00	12.00	51.60[a]	42.41[a]	84.27	75.00	66.00[a]	46.70[a]
Carbonate of lime	144.0	116.00	86.14	29.20	141.82[a]	52.84	32.00	32.00	68.80[a]	101.26[a]	41.60	26.00	84.00[a]	68.00[a]
Silica	tr.	.....	.47	8.00	1.16	.....	little	little	.84	3.25	.....	.....	.....	.....
Sulphate of soda	.....	.....	0.65	1.76	.....	1.48	.....	.....	1.68	.....	.....	.....	.....	.....
Carbonate of iron	.....	.....	0.84	.....	tr.	3.51	8.00	8.00	7.00[a]	.....	5.45	1.00	.....	.....
Total	626.4	558.80	537.75	486.56	485.51	.....	600.00	564.00	358.24	165.78	387.74	291.00	340.00	397.1
Carbonic acid gas, cu. in	312.8	.....	284.65	244.00	359.50	.....	168.00	.....	326.40	.....	344.16	326	.....	.....
Azote	7.2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Temperature ° F	.....	.....	.....	50° F.	.....	.....	51°–52°F	.....	.....	.....	.....	.....	.....	.....

NOTES. The first analysis is by J. F. Dana and was made before 1817. This analysis is by mistake attributed to J. D. Dana in Bulletin 32, page 38, United States Geological Survey. The second analysis is by Davy and Faraday, London, as cited in Bulletin 32, United States Geological Survey, page 38. The date is not given but it was obviously early. There was also potassium bromid, tr. sodium iodid, 4.02, iron oxid, 0.64. The third analysis is by J. R, Chilton (1834). There was also potassium and sodium bromid, 5.92; alumina, 0.32, atmospheric air, 5.41 cubic inches. The fourth analysis of the United States spring is by L. C. Beck. Mineralogy of New York, 137 (1842). No. 5 was by E. Emmons and is quoted in Bulletin 32, page 38. There was also 12.0 of sodium iodid or iodine. No. 6 is by J. R. Chilton (1840) and is taken from Bulletin 32, United States Geological Survey, page 40. It contained calcium phosphate, 0.19; potassium bromid and sodium iodid, 2.59; alumina, 0.42; atmospheric air, 5 30 cubic inches. The first analysis of the Albany spring is by William Meade M.D.; the second by L. C. Beck. Both are taken from Beck's Mineralogy of New York, 140 1842. The spring is in Albany, N. Y., not Saratoga. No. 9 by J. R. Chilton (1840) and is taken from Bulletin 32, United States Geological Survey, page 40. It contained also sodium phosphate, 0.21, potassium bromid, tr.; sodium iodid, 2, alumina, 56, atmospheric air, 6.40 cubic inches. No. 10 by Appleton, date not given in Bulletin 32, United States Geological Survey, page 40. Also potassium chlorid, 6.86 iron oxid and alumina, 2.10. No. 11 by J. R. Chilton (1841) taken from Bulletin 32, United States Geological Survey, page 41. Also sodium iodid, 3.60; alumina and silica, 1.57. Atmospheric air, 4.62 cubic inches. No. 12 by E. Emmons (1839). The spring is also called the Iodine or Star. Analysis taken from Bulletin 32, United States Geological Survey, page 41. Also sodium iodid, 3.50. Atmospheric air, 4 cubic inches. No. 13 by J. R. Chilton (1843). Analysis furnished by J. C. Minor, jr. No. 14 by E. Emmons. Analysis furnished by J. C. Minor, jr.

a Bicarbonates.

TABLE 4

Analyses in grains per U. S. gallon made by Dr Charles F. Chandler, 1860–1875, and taken from F. A. Cairn's Notes on Quantitative Analysis

	GLACIER SPOUTING WELL	GEYSER SPOUTING WELL	HATHORN	UNION	CONGRESS	PAVILION	EMPIRE	HIGH ROCK
Chlorid of sodium	702.239	562.080	509.968	458.299	400.444	459.903	506.630	390.127
Chlorid of potassium	40.446	24.634	9.597	8.733	8.049	7.660	4.292	8.974
Bromid of sodium	3.579	2.212	1.534	1.307	8.559	0.987	0.266	0.731
Iodid of sodium	0.234	0.248	0.198	0.039	0.138	0.071	0.606	0.086
Fluorid of calcium	tr.	tr.	tr.	tr.	tr.	tr.	tr.	tr.
Bicarbonate of lithia	6.247	7.004	11.447	2.605	4.761	9.486	2.080	1.967
" " soda	17.624	71.232	4.288	17.010	10.775	3.764	9.022	34.888
" " magnesia	193.972	149.343	176.463	109.685	121.757	76.267	42.953	54.924
" " lime	227.070	170.392	170.646	96.703	143.399	120.169	109.656	131.739
" " strontia	0.082	0.425	tr.	tr.	tr.	tr.	tr.	tr.
" " baryta	2.083	2.014	1.737	1.703	0.928	0.875	0.070	0.494
" " iron	0.647	0.979	1.128	0.269	0.340	2.570	0.793	1.478
Sulphate of potassa	0.252	0.318	tr.	1.818	0.889	2.032	2.769	1.608
Phosphate of soda	0.010	tr.	0.006	0.026	0.016	0.007	0.023	tr.
Biborate of soda	tr.	tr.	tr	tr.	tr.	tr.	tr.	tr.
Alumina	0.458	tr.	0.131	0.324	tr.	0.329	0.418	1.223
Silica	0.699	0.665	1.260	2.653	0.840	3.155	1.458	2.260
Organic matter	tr.	tr.	tr.	tr.	tr.	tr.	tr.	tr.
Total	1 195.582	991.546	888.403	701.174	700.895	687.275	680.436	630.500
Carbonic acid gas	465.458	454.082	375.747	384.969	392.289	332.458	344.669	409.458
Density	.....	1.012	1.0115	.....	1.096	1.0095	.....	1.0092
Temperature	.....	46° F.	.....	48° F.	52° F.	.....	.....	52° F.

TABLE 4 (*concluded*)

Analyses in grains per U. S. gallon made by Dr Charles F. Chandler, 1860–1875, and taken from F. A. Cairn's Notes on Quantitative Analysis

	STAR	CRYSTAL	VICHY	UNITED STATES	SELTZER	BALLSTON ARTESIAN LITHIA	FRANKLIN ARTESIAN	CONDE DENTONIAN
Chlorid of sodium	398.361	328.468	128.689	141.872	134.291	750.030	659.344	645.481
Chlorid of potassium	9.695	8.327	14.113	8.624	1.335	33.276	33.930	9.232
Bromid of sodium	0.571	0.414	0.990	0.844	0.630	3.643	4.665	2.368
Iodid of sodium	0.126	0.066	tr.	0.047	0.031	0.124	0.235	0.225
Fluorid of calcium	tr.	tr.	tr.	tr.	tr.	tr.	tr.	tr.
Bicarbonate of lithia	1.586	4.326	1.760	4.847	0.899	7.750	6.777	10.514
" " soda	12.662	10.064	82.873	4.666	29.428	11.928	94.604	34.400
" " magnesia	61.912	75.161	41.503	72.883	40.339	180.602	177.868	158.348
" " lime	124.459	101.881	95.522	93.119	89.869	238.156	202.332	178.484
" " strontia	tr.	tr.	tr.	0.018	tr.	0.867	0.002	0.189
" " baryta	0.096	0.726	0.593	0.909	tr.	3.881	1.231	4.739
" " iron	1.213	2.038	0.052	0.714	1.703	1.581	1.609	2.296
Sulphate of potassa	5.400	2.158	tr.	tr.	0.557	0.520	0.762	tr.
Phosphate of soda	tr.	0.009	tr.	0.016	tr.	0.050	0.011	0.003
Biborate of soda	tr.	tr.	tr.	tr.	tr.	tr.	tr.	tr.
Alumina	tr.	0.305	0.473	0.094	0.374	0.077	0.263	0.395
Silica	1.283	3.213	0.758	3.184	2.561	0.761	0.735	1.026
Organic matter	tr.	tr.	tr.	tr.	tr.	tr.	tr.	tr.
Total	617.367	537.155	367.326	331.837	302.017	1 233.246	1 184.368	1 047.700
Carbonic acid gas	407.650	317.452	383.071	245.734	324.080	423.114	460.066	358.345
Density	1.0091	1.006	.....	1.0035	1.0034	1.0159	1.0135	1.0125
Temperature	52° F.	50° F.	50° F.	.....	50° F.	52° F.	52° F.	49° F.

TABLE 5

Analyses of Saratoga waters by Dr Charles F. Chandler, recast as ions in parts per million

	GLACIER SPOUTING	GEYSER SPOUTING	HATHORN	UNION	CONGRESS	PAVILION	EMPIRE	HIGH ROCK	STAR	CRYSTAL	VICHY	UNITED STATES	SELTZER
Cl	7 571.8	5 997.6	5 338.0	4 797.4	4 195.6	4 806.2	5 242.2	4 097.3	4 188.2	3 456.1	1 441.8	1,533.4	1 396.2
Br	47.6	28.9	20.4	17.3	112.9	13.1	1.9	9.7	7.5	5.5	13.0	11.2	8.5
I	3.4	3.6	2.7	0.6	2.0	1.0	8.7	1.2	1.8	0.9	tr.	0.6	0.4
HCO_3	6 059.5	5 374.0	4 993.2	3 094.0	4 519.9	2 877.9	2 189.4	2 977.6	2 694.5	2 618.0	2 896.0	2,398.1	2 142.0
SO_4	2.4	3.0	tr.	17.0	8.4	19.0	25.9	15.1	50.7	20.2	tr.	0.2	5.2
PO_4	0.1	tr.	0.1	0.3	0.2	0.1	0.3	tr.	tr.	0.1	tr.	0.2	tr.
SiO_2	11.9	11.9	21.4	45.1	14.3	53.6	24.8	38.4	21.8	54.6	12.8	54.1	43.5
Na	4 790.6	4 267.0	3 435.7	3 148.4	2 759.1	3 095.3	3 450.2	2 774.7	2 724.1	2 244.2	1 249.7	973.4	1 037.0
K	392.1	221.0	85.0	93.5	78.2	83.8	59.5	92.1	127.5	90.6	125.8	76.7	16.1
Li	10.2	11.9	20.4	4.6	8.5	16.7	3.6	3.4	2.8	7.6	3.1	8.5	1.6
Ca	945.2	710.8	712.3	402.9	598.4	501.3	457.3	549.6	603.5	425.0	397.8	388.6	374.9
Ba	18.4	18.4	15.8	15.4	8.4	7.9	0.6	4.5	0.9	6.6	5.4	8.2	tr.
Sr	.6	2.7	tr.	tr.	tr.	tr.	tr.	tr.	tr.	tr.	tr.	0.1	tr.
Ng	592.6	417.1	492.7	306.5	340.3	213.2	120.1	153.5	173.4	210.0	115.9	203.7	112.7
Fe	3.5	5.4	6.8	1.4	1.9	14.1	4.4	8.1	6.7	11.2	0.2	3.9	9.5
Al	4.1	tr.	1.2	2.9	tr.	3.1	3.8	11.1	tr.	2.8	4.1	0.8	3.4
Total	20 325.0	16 856.0	15 102.8	11 920.0	11 915.0	11 583.5	11 567.2	10 718.5	10 495.0	9 132.4	6 244.5	5 641.0	5 134.0

TABLE 6

Various analyses of date later than 1850. Grains per gallon

	1 EUREKA	2 EXCELSIOR	3 HAMILTON	4 KISSINGEN	5 KISSINGEN	6 SARATOGA A	7 CONGRESS	8 CONGRESS	9 HATHORN	10 STAR
Sodium chlorid	166.81	370.64	298.66	338.50	135.5	65.30	550.8	406.6	478.7	124.5
" iodid	4.67	4.24	3.59	0.04	.....	.....	.....	.....	.....	.....
" bicarbonate	8.75	15.00	34.25[a]	67.62	76.6	6.75	10.9	15.5	17.6	4.2
" sulphate	.....	1.32	.....	.....	.....	2.50	.....	.....	.....	.....
Potassium chlorid	.....	.....	.....	16.98	16.9	0.36	26.1	40.0	32.8	0.0
" bromid	1.57	tr.	.....	.....	.....	.....	.....	.....	.....	.....
Calcium bicarbonate	41.32	77.00	97.99[a]	140.26	40.2	56.85	149.8	88.1	147.2	31.7
Magnesium bicarbonate	29.34	32.33	39.06[a]	70.47	70.4	20.48	138.1	42.1	130.5	9.4
" sulphate	2.15	.....	.....	.....	.....	0.29	.....	.....	.....	.....
Iron bicarbonate	3.00	3.22	4.62[a]	1.56	.....	1.72	.....	.....	.....	.....
Alumina	0.23	.....	.....	tr.	.....	0.38	.....	.....	.....	.....
Silica	0.53	.....	1.00	1.28	.....	1.46	.....	.....	.....	.....
Total	258.37	503.75	479.17	636.71	339.6	.....	875.7	592.3	806.8	169.8
Carbonic acid gas, cubic inches	239.00	250	320	361.50	.....	.....	.....	.....	.....	.....
Atmospheric air, cubic inches	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

No. 1, Allen, analyst, United States Geological Survey, Bulletin 32, page 39. No. 2, Allen, analyst (1879), idem. Also strontium sulphate, tr., sodium silicate, 4; potassium silicate, 7.00. No. 3, Allen, analyst, as under No. 1. No. 4, Sharples, analyst (1872), as under No. 1. Also strontium bicarbonate, tr.; lithium bicarbonate, 5.13; barium bicarbonate, 0.99; potassium sulphate, tr.; sodium bromid, 1.80; calcium fluorid, tr. No. 5, Nichols (1896), from J. C. Minor, jr. No. 6, J. G. Pohle, analyst, as under No. 1. Also lithium bicarbonate, 1.72; calcium sulphate, 0.45; potassium sulphate, 0.37; calcium chlorid, tr.; magnesium chlorid, tr.; organic matter, tr. No. 7, L. W. Mears (1892), from J. C. Minor, jr. No. 8, Wheeler (1906), from J. C. Minor, jr . No .9, C. F. Chandler (1884), from J. C. Minor, jr. No. 10, Smith (1904), from J. C. Minor, jr. No. 11, Ellery (no date), from J. C. Minor, jr.

a Normal carbonate, not bicarbonate.

TABLE 6 (*concluded*)

Various analyses of date later than 1850. Grains per gallon

	11 HIGH ROCK	12 VICTORIA	13 LINCOLN	14 MAGNETIC	15 CARLSBAD 3	16 CARLSBAD 1	17 CHIEF	18 PUTNAM	19 STRONG	20 AINSWORTH
Sodium chlorid	86.8	186.2	315.2	69.0	486.7	670.5	86.9	210.9	265.2	448.1
" iodid	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
" bicarbonate	19.7	32.8	32.8	16.0	52.5	12.0	74.1	19.8	68.9	5.7
" sulphate	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Potassium chlorid	1.1	16.1	22.9	8.0	33.5	45.2	6.5	2.3	24.8	6.2
" bromid	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Calcium bicarbonate	20.4	112.5	176.2	86.7	173.7	218.2	72.2	109.4	123.9	100.2
Magnesium bicarbonate	8.1	79.8	108.5	35.0	118.1	155.0	53.6	63.1	79.2	146.8
" sulphate	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Iron bicarbonate	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Alumina	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Silica	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total	136.1	427.4	655.6	214.7	864.5	1,100.9	293.3	405.5	562.0	707.0
Carbonic acid gas, cubic inches	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Atmospheric air, cubic inches	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

No. 12. Perkins (no date), from J. C. Minor, jr. No. 13. Perkins (1896), from J. C. Minor, jr. No. 14. Duffield (no date), from J. C. Minor, jr. No. 15. Smith (1901), from J. C. Minor, jr. No. 16. C. F. Chandler (1887), from J. C. Minor, jr. No. 17. Perkins (no date), from J. C. Minor, jr. No. 18. Perkins (1891), from J. C. Minor, jr. No. 19. Perkins (1902), from J. C. Minor, jr. No. 20. L. W. Mears (1889), from J. C. Minor, jr.

TABLE 7

Analyses of Saratoga waters by J. K. Haywood and B. H. Smith, United States Department of Agriculture, 1905. Parts per million in ions.

	HATHORN	CARLSBAD	LINCOLN	HATHORN	CONGRESS	CHIEF	GEYSER	CHAMPION	PEERLESS
Cl	4 674.7	4 419.6	4 068.4	3 685.5	3 327.9	2 982.7	1 025.1	2 799.1	1 773.1
Br	47.1	40.3	76.0	26.9	26.8	20.2	11.8	13.5	16.8
I	1.7	1.6	1.9	1.5	0.8	1.2	1.0	0.2	1.0
HCO_3	4 147.1	4 244.5	4 221.0	3 585.6	3 573.3	3 966.7	4 353.2	1 604.3	2 634.4
SO_4	3.4	2.8	3.5	5.6	8.7	5.3	1.4	20.0	4.0
PO_4	.....	.....	.....	.....	.....	.....	.....	.....	.....
SiO_2	16.2	13.5	32.7	19.6	19.8	15.0	20.8	12.3	14.8
Na	2 951.8	3 014.5	2 688.0	2 430.7	2 199.3	2 182.0	2 010.9	1 839.9	1 298.5
K	197.8	237.8	243.7	197.2	192.0	197.7	29.0	60.0	94.7
Li	7.4	5.3	1.8	0.5	5.4	2.8	3.6	0.9	0.4
Ca	765.0	628.6	675.8	650.7	562.1	601.4	116.4	348.3	530.4
Ba	7.5	10.1	11.7	5.5	7.1	1.1	2.6	6.3	2.1
Sr	.....	tr.	.....	tr.	.....	.....	tr.	.....	.....
Mg	328.0	298.8	325.9	228.8	278.2	217.1	60.6	81.1	90.9
Fe Al	6.7	13.1	13.9	9.8	14.7	3.7	8.4	.8	5.6
NO_3	.....	.....	tr.	.....	.....	.....	tr.	tr.	.....
NO_2	tr.	.....	.....	.....	tr.	tr.	.....	.....	tr.
Mn	.....	.....	.....	.....	.....	.....	.....	tr.	.....
NH_4	12.8	13.4	7.3	10.7	10.3	8.9	11.4	3.1	5.9
Total	13 170.3	12 949.6	12 371 .6	10 858.6	10 232.7	10 207.0	7 656.2	6 790.2	6 472.6

TABLE 7 (*concluded*)

Analyses of Saratoga waters by J. K. Haywood and B. H. Smith, United States Department of Agriculture, 1905. Parts per million in ions.

	MAGNETIC	ARONDACK	STAR	SELTZER	VICTORIA	VICHY	VICHY	HIGH ROCK	HIDE'S FRANKLIN, BALLSTON
Cl	1 313.4	1 185.9	1 325.8	720.1	1 238.8	915.0	893.3	483.3	7 179.0
Br	11.8	11.8	0.2	6.7	20.2	tr.	tr.	6.7	60.0
I	0.3	none	tr.	0.3	tr.	tr.	tr.	.2	2.3
HCO_3	1 816.8	275.5	472.4	1 114.3	365.2	778.2	684.3	1 114.0	6 566.0
SO_4	2.3	593.9	47.0	20.2	27.1	20.2	16.7	15.7	3.0
PO_4	.....	.....	2.3	.....	.....	.....	.....	.....	.....
SiO_2	42.7	9.2	13.7	40.4	14.8	16.2	14.7	33.4	27.6
Na	849.7	827.3	878.1	459.6	822.0	828.8	772.1	348.0	4 833.0
K	56.9	144.7	23.1	48.4	140.4	3.9	3.8	34.3	346.0
Li	3.2	2.5	tr.	0.1	0.2	0.1	0.6	0.9	15.5
Ca	326.4	25.7	120.5	247.0	8.9	48.7	41.3	223.9	991.0
Ba	4.4	0.1	0.4	0.7	.....	.....	0.1	0.7	13.1
Sr	tr.	.....	.....	.....	.....	.....	.....	.....	tr.
Ng	122.8	90.6	25.4	67.5	21.6	10.1	9.1	60.6	469.0
Fe Al	97.8	3.5	3.2	5.1	4.2	2.2	4.2	12.3	21.4
NO^3	tr.	11.9	44.3	4.4	.....	.....	tr.	6.6	.....
NO_2	tr.	0.02	tr.	tr.	.....	.....	tr.	.....	.....
Mn	.....	.....	.....	.....	.....	.....	.....	.....	tr.
NH_4	3.4	0.2	0.3	2.6	0.1	0.9	0.7	1.5	14.5
Total	4 675.9	3 094.2	2 958.0	2 736.8	2 663.5	2 629.2	2 440.9	2 347.2	20 542.6

Analyses of the salts dissolved in the spring waters of Saratoga and Ballston

SPRING		ANALYST	NA CL	CA $(HCO_3)_2$	MG $(HCO_3)_2$	NA HCO_3	KCL	TOTAL	GRAINS PER GALLON
Ainsworth	'89	Mears	63.3	14.2	20.8	.8	.9	100.	707.0
Arondack	'88	Sharples	53.5	22.1	11.0	10.6	2.7	99.9	633.6
"	'96	Nichols	39.9	11.8	20.6	22.4	5.0	99.7	339.6
"	'03	Hayward	74.3	4.4	10.0	.....	11.2	99.9	134.7
Ballston Act.	'71	Chandler	62.0	19.6	14.9	1.0	2.7	100.2	1213.9
" Frankl.	'71	"	56.4	17.6	15.2	8.1	2.9	100.2	1167.9
Carlsbad 1	'87	Chandler	61.0	19.8	14.1	1.1	4.1	100.1	1100.9
Carlsbad 3	'01	Smith	56.0	20.0	13.7	6.1	3.9	99.7	864.5
"	'03	Hayward	54.0	20.0	14.2	8.7	3.2	100.1	742.3
Champion	'72	Chandler	59.2	19.2	16.4	1.5	3.4	99.7	1181.1
"	'03	Hayward	67.5	21.0	7.3	2.7	1.4	99.9	390.2
Chief	'98	Perkins	29.8	24.6	18.3	25.2	2.2	100.1	293.3
"	'03	Hayward	45.5	24.6	13.0	13.5	3.3	100.2	587.3
Coesa	'11	N. Y. Dept. of Health	49.4	24.5	9.8	12.2	4.0	99.9	707.5
Columbian	?	Emmons	67.4	17.2	11.8	3.9	.....	100.3	397.1
Congress	'30	Steel	59.5	24.2	14.8	1.4	.....	99.9	647.0
"	'43	Chilton	56.0	21.4	21.0	1.7	.....	100.2	650.6
"	'71	Chandler	58.4	20.9	17.7	1.5	1.1	99.6	684.1
"	'92	Mears	63.5	17.2	15.8	1.2	3.0	100.7	875.7
"	1902	Hayward	51.3	22.4	16.6	6.3	3.4	100.0	585.5
"	1906	Wheeler	68.6	14.9	7.1	2.6	6.8	100.0	592.3
Empire	'52	Emmons	54.8	28.8	8.5	7.9	.....	100.0	493.1
"	'71	Chandler	75.0	16.2	6.4	1.3	0.6	99.5	672.4
Eureka	?	Allen	68.0	16.7	11.9	3.5	.....	100.1	246.1
Flat Rock	'30	Steel	48.0	31.2	13.8	6.8	.....	99.8	310.0
" "	'71	Chandler	43.0	38.6	11.5	3.6	3.1	99.8	253.8
Geyser	'71	Chandler	57.5	17.4	15.3	7.3	2.5	100.0	977.4
"	1903	Hayward	21.2	6.3	4.8	67.3	0.5	100.1	437.6
Hamilton	'30	Steel	65.7	20.4	7.8	6.1	.....	99.9	451.9
Hathorn	'71	Chandler	58.6	19.6	20.2	.5	1.1	100.0	870.6
"	'84	"	59.1	18.2	16.1	2.2	4.1	99.7	806.8
Hathorn	1902	Hayward	56.5	23.8	15.6	1.4	2.9	100.2	757.5
"	1903	"	53.5	24.5	12.9	5.5	3.4	99.8	625.7
Hathorn No. 2.	1911	N. Y. State Dept. of Health	52.4	19.8	14.5	12.7	.6	100.0	1216.1
High Rock	'30	Steel	56.1	20.5	18.4	5.0	.....	100.0	337.0

Analyses of the salts dissolved in the spring waters of Saratoga and Ballston—(*continued*).

SPRING		ANALYST	NA CL	CA $(HCO_3)_2$	MG $(HCO_3)_2$	NA HCO_3	KCL	TOTAL	GRAINS PER GALLON
High Rock	'71	Chandler	63.0	21.0	8.9	5.7	1.5	100.1	620.4
" "	1903	Hayward	33.2	40.6	16.2	7.6	2.7	100.3	129.4
" "	1906?	Ellery	64.0	14.7	5.9	14.5	.8	99.9	136.1
Lincoln	'96	Perkins	48.0	27.0	16.5	5.5	3.5	100.5	655.6
"	1903	Hayward	52.6	22.7	15.8	5.4	3.2	99.7	704.6
Magnetic	?	Duffield	32.1	40.3	16.3	7.5	3.7	99.9	214.7
"	1903	Hayward	47.0	30.4	16.7	3.4	2.2	99.7	253.8
Paterson	'88	Chandler	52.0	24.8	17.1	3.5	2.2	99.6	519.0
Pavilion	'40	Chilton	49.3	22.5	26.0	.....	2.1	99.9	379.7
"	'71	Chandler	69.0	18.0	11.4	.6	1.2	100.2	667.5
Peerless	'88	Chandler	46.4	31.6	13.3	6.1	2.5	99.9	412.1
"	1903	Hayward	43.4	33.8	8.6	11.8	2.5	100.1	371.5
Putnam	?	Chandler	43.0	25.2	27.9	1.3	2.4	99.8	621.9
"	'91	Perkins	52.0	27.0	15.5	4.9	.6	100.0	405.5
Red	?	Appleton	33.1	40.4	17.0	6.1	2.7	99.3	249.3
Royal	'88	Chandler	52.0	28.7	16.0	1.2	1.8	99.7	508.9
Saratoga A	'65	Pohle	87.0	8.8	3.1	1.0	.6	100.5	649.7
Seltzer	'71	Chandler	45.5	30.4	13.7	10.0	.4	100.0	295.0
Star	'71	Chandler	65.5	20.5	10.2	2.1	1.6	99.9	606.8
"	'95	"	41.7	36.2	14.5	5.6	2.1	100.1	328.8
"	1903	Hayward	76.8	17.2	4.6	.....	1.2	99.8	162.7
"	1904	Smith	73.0	18.8	5.5	2.5	.....	99.8	169.8
Strong	1902	Perkins	47.0	22.0	14.1	12.3	4.5	99.9	562.0
Union	'71	Chandler	66.3	14.1	16.0	2.5	1.3	100.2	685.4
Vichy	'71	Chandler	35.4	26.4	11.2	22.9	3.9	99.8	362.5
"	1902	Hayward	58.3	6.4	2.4	33.0	0.3	100.4	149.4
"	1903	"	61.6	6.7	2.3	29.1	0.3	100.0	138.0
Victoria	'90	Perkins	43.5	26.2	18.7	7.7	3.9	100.0	427.4
"	1903	Hayward	72.0	1.4	5.0	11.8	9.8	100.0	148.8
Washington	'30	Steel	58.0	30.4	8.5	3.3	.....	100.2	485.0
"	'43	Chilton	53.5	24.7	19.5	2.3	.....	100.0	340.0

NOTE. The above analyses were chiefly compiled by J. C. Minor, Jr. To Mr Minor's original series a few very recent ones have been added. Thanks are due Mr Minor for the use of his notes.

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New York State Museum

JOHN M. CLARKE, Director

Museum Bulletin 160

THE GLACIAL WATERS IN THE BLACK AND MOHAWK VALLEYS

BY

HERMAN L. FAIRCHILD

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New York State Education Department
Science Division, September 9, 1911

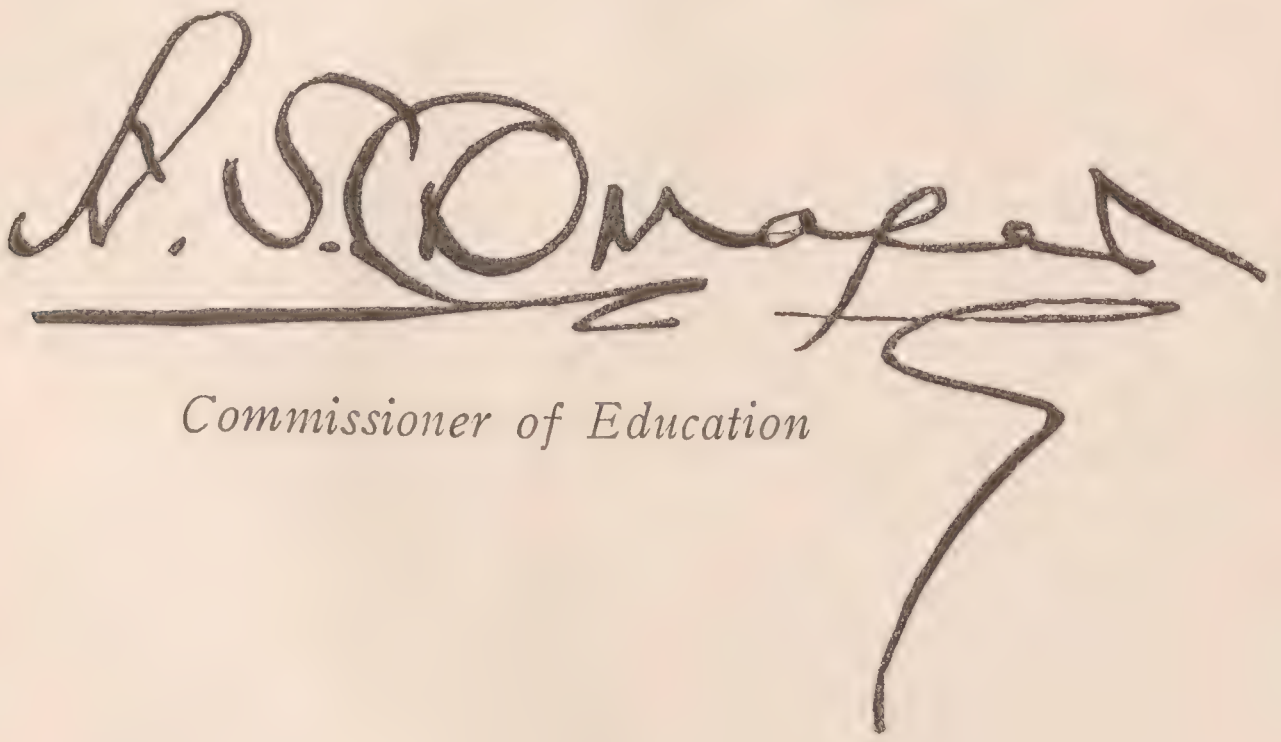
Hon. Andrew S. Draper LL.D.
Commissioner of Education

SIR: I have the honor to transmit to you herewith the manuscript and maps of a report entitled *The Glacial Waters in the Black and Mohawk Valleys,* prepared by Doctor Herman L. Fairchild, a member of the staff of this division, in continuation and completion of his study of the development of the water system of the State, and I recommend that it be published as a bulletin of the State Museum.

Very respectfully
JOHN M. CLARKE
Director

STATE OF NEW YORK
EDUCATION DEPARTMENT
COMMISSIONER'S ROOM

Approved for publication this 12th day of September 1911



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THE GLACIAL WATERS

IN THE

BLACK AND MOHAWK VALLEYS

BY

SHERMAN L. FAIRCHILD

INTRODUCTION: OUTLINE OF THE GLACIAL HISTORY

This paper is essentially a continuation of the one forming State Museum Bulletin 127, "Glacial Waters in Central New York." In that paper was given the history of the glacial lakes and the ice-border drainage as far east as Oneida. While the features there described are quite clear as to their origin, the relationship of the phenomena in time and causality are somewhat uncertain, in the present state of our knowledge of the behavior of the ice margin during its recession across the State. It was there stated that the oscillations of the glacier were probably greater and the history more complicated than now recognized. In the present writing there is similar complication, with the additional problem of correlating the sequence of events in the Ontario basin with those in the Mohawk and Hudson valleys. For the Black river basin the history is comparatively clear, but not so for the Mohawk-Hudson. The writer aims to give an outline of the dramatic history and lay the foundation for future detailed work.

The study of the Black valley was mainly during the summers of 1907 and 1908, though some features had been noted in earlier years. It was the intention to submit the matter for publication in 1908 but the need of revision of the Watertown sheet caused delay and it is included here.

A concise outline of the history described in the following writing will be helpful to the reader. As the large physiographic relief we have the elevated tract of the Adirondacks surrounded by low and broad valleys; the Champlain-Hudson on the east, the Mohawk on the south, the Ontario on the southwest and west, and the St Lawrence on the northwest and north. The highest point in all this ring of lowland is the col at Rome, about 430 feet above tide, the head of the Mohawk valley which is the connecting channel between the Ontario and Hudson valleys.

As the Labradorian ice body, which had at its maximum covered practically the entire State, waned and lost in thickness the Adirondack heights appeared above the ice field, standing as an island in the ice sheet, although local or stream glaciers probably occupied for a time some of the higher valleys. The high Catskill-Helderberg mass must have already been deserted by the ice sheet, and consequently there was left a strait or neck of ice in the Mohawk valley connecting the Ontarian and Hudsonian ice lobes. This stage in the ice retreat is shown in plate 12.

The removal of the ice was partly by evaporation but chiefly by melting and water must have collected about the base of the Adirondack island, forming a chain of lakes in the depressions. This water would fill all the crevasses in the ice margin and to some extent would penetrate in and beneath the shallower ice, but it is not believed possible for the water to have found escape through or beneath the deep ice which lay in the Ontario and Hudson valleys. Its only possible ultimate escape must have been over and across the strait of ice south of the Adirondacks. Some of the extensive sand plains, even in the heart of the mountains and with altitude over 1400 feet, must belong to this episode in the drainage.

With the continued waning of the ice body the neck of ice in the Mohawk valley was melted away and was supplanted by a lake held between the two opposing ice lobes, the Hudsonian lobe pushing up the Mohawk valley from the east and the Ontarian lobe blocking the valley on the west. This stage is shown in plates 13–15.

The Mohawk glacial waters were lowered and finally extinguished by the weakening and recession of the Hudsonian ice in the vicinity of Schenectady (see plates 14–16).

Contemporary with the Mohawk glacial waters were waters held in the valley of the Black river by the ice blockade on the north, with earlier outflow southward into the Mohawk lakes. The later escape of the Black waters was westward into Lake Iroquois, in the vicinity of Copenhagen and Carthage (see plate 17).

The glacial lake history of the Mohawk valley must have been contemporaneous with only the earlier glacial waters in central New York, lakes Watkins and Newberry (see no. 19 of the bibliographic list, Bulletin 127, and plates 34, 35), for the reason that the central New York waters of later time found free eastward escape through the Mohawk valley at the lowest levels.

Doubtless there were readvances and reretreats of the ice fronts and restorations of the lakes which we can not now recognize, but finally the Ontarian ice permanently receded from the Oneida-Rome district and Lake Iroquois was established with its long-continued outlet at Rome to the Mohawk-Hudson.

As the territory involved in this history has considerable north and south distance it is necessary to recognize the deformation or warping of the land which has taken place since the ice removal. It is certain that in the Ontario district a northward lifting of two or three feet per mile has occurred. In this paper the northward uplift is counted as two feet per mile, in correlation of altitudes, which corresponds to the figure used by Professor Woodworth for the Hudson district. The east and west deformation is so small that for the present it is neglected.

To save repetition the terms col, notch and pass are used as equivalents in this writing; and when a pass was occupied by a river it is termed outlet, channel, or escape.

BLACK VALLEY GLACIAL WATERS

PHYSIOGRAPHY

New York State, because of its peculiar physiography, probably surpasses any other district of equal area in the world in the number and excellence of its Pleistocene glacial lakes. Taking into account the several elements involved in the production and life of a glacial lake, the ice-dammed waters held in the basin of the Black river, in Jefferson and Lewis counties, affords one of the finest examples. The reasons for this excellence lie in the favorable attitude, direction, dimensions and relations of the valley; the simplicity and clearness of its history; the three distinct stages with different directions of overflow; the pronounced channels and deltas due to the outdrainage; and the remarkable development of sand plains built on the east wall of the valley by the indrainage from the Adirondacks.

The Genesee valley waters probably have no rival in the world in the number of distinct stages, nor in the number of far-separated great river systems to which the waters at different times were contributed; but the greater simplicity of the Black valley lake makes it a more typical and suitable example for study.

The district involved in this history is partially mapped in Sackett Harbor, Watertown, Carthage, Port Leyden, Boonville, Remsen and Oriskany sheets of the State topographic map. The map of the quadrangle north of the Port Leyden and east of the Carthage sheets is not yet available. The drainage of the area is shown in the sketch map, plate 1, while details are shown in plates 2–4.

The Black river carries the heavy drainage of a large area on the west slope of the Adirondack highland. The river has its source in the district of Ice Cove mountain, in the east edge of Herkimer county, North lake being an expansion of its headwaters. For something over 20 miles its course lies southwest, when it swings to northwest passing through Forestport and Hawkinsville. In this upper reach of about 30 miles the river has no pronounced valley, but some three miles past Hawkinsville, and three miles east of Boonville, it enters the head of the conspicuous and capacious valley which popularly bears its name. This valley extends northwest 40 miles to Carthage where it opens into the broad St Lawrence lowland. From Carthage the river curves around to the west and flowing through open country with only a shallow, postglacial channel, passes through the city of Watertown, and enters Lake Ontario at Dexter, near Sackett Harbor.

KEY MAP
GLACIAL WATERS
IN THE
BLACK AND MOHAWK VALLEYS
H. L. FAIRCHILD
1909
The heavy lines show the divides, crossed by the outlets of glacial waters.
Scale 1/950 400
Miles
0 5 10 15 30 45
76°
75°
74°
44°
43°
42°
Cape Vincent
Black River
Watertown
Sacketts Harbor
Carthage
Copenhagen
Lorraine
Lowville
Monteola
Pulaski
Boonville
Camden
Fulton
Oneida Lake
Rome
Oneida
Syracuse
Marcellus
Manlius
Clinton
Utica
Trenton Falls
Wilmurt
Herkimer
Little Falls
Dolgeville
Morrisville
Hamilton
Tully
Skaneateles L.
Otisco L.
Cortland
Norwich
New Berlin
Richfield Springs
Cherry Valley
Cooperstown
Oneonta
Susquehanna Riv.
Walton
Delhi
Bloomville
Schoharie
Middleburg
Hunter
Catskill
Phoenicia
Albany
Schenectady
Amsterdam
Fonda
Johnstown
Gloversville
Northville
Lake Pleasant
North Creek
Schroon L.
Indian L.
Raquette Lake
Long Lake
Wanakena
Fulton Chain of Lakes
Mohawk River
MOUNTAINS
CATSKILL MOUNTAINS
OSWEGO
ONONDAGA
CORTLAND
MADISON
CHENANGO
ONEIDA
LEWIS
HERKIMER
HAMILTON
FULTON
MONTGOMERY
SCHENECTADY
SARATOGA
WARREN
OTSEGO
SCHOHARIE
ALBANY
GREENE
DELAWARE
800
1000
1200
1130
1220
1150
1360
1500
1580
1900
2040
1920
760
840

A series of parallel streams from the Adirondacks joins the Black river on the east, two of which, the Moose and Beaver, are even larger than the Black river proper. Three factors produce this heavy drainage: the large area, the high altitude and the west-facing attitude, the two latter producing the condensation of moisture from the prevailing westerly winds. In glacial time the wind direction was probably similar to the present and we have every evidence that in this area the precipitation and drainage were very large.

The tributaries to the river from the west are short and weak, with the exception of the Deer river which joins a few miles above Carthage. The lack of western tributaries is due to the narrowness and steepness of the west wall of the basin and its lee position with reference to moisture-laden winds.

The prominent physiographic feature of the Black river basin is the Boonville-Carthage valley. Boonville is situated at the lowest col or pass between Black river waters and drainage to the Mohawk, through the Lansing kill, the altitude of the divide being about 1130 feet. (The summit level of the canal, in a rock cut, is 1120.) Carthage lies on the west side of the mouth of the valley, with altitude of 740 feet on the river bridge.

The west wall of the valley rises steeply in scarps and terraces of limestone until capped by shales at the height of 1800 to 1900 feet. The east wall, with irregular topography, rises slowly into the Adirondacks. The topographic contrast between the two sides of the valley is well shown in plate 3.

The mantle of drift on the west valley wall is scanty; but on the east slope the glacio-lacustrine deposit is remarkably heavy (see p. 15). Crystalline rocks underlie the east slope and the valley bottom and appear in places along the foot of the west slope, conspicuous from the railroad. Bosses of the crystallines project up through the alluvium of the valley, producing the peculiar topography indicated by the contouring on the Carthage sheet east and north of the city. These protruding masses, developed by atmospheric erosion in preglacial time and rubbed into smoothness by the ice abrasion and then half buried in stream and lake deposits, are conspicuous features at many points in the valley. Tens of thousands of huge blocks of the crystallines have been spread by the glacier over the country to the southward, especially along the moraine belt extending southeast from Boonville, as shown in plate 18.

Apparently this great north-sloping valley of the Black river was developed by millions of years of weathering and stream work

along the belt of contact between the old crystallines and the onlapping Ordovicic sediments; and during the development of the valley the axis of the valley has shifted westward against the outcrop of the sedimentaries.

OUTLINE OF THE LAKE HISTORY

This history is concerned with the waning and disappearance from the region of the latest or Wisconsin ice sheet, though it is quite probable that this history may be a duplication of that of earlier ice recessions. Some topographic features, like those in the Watertown district (the Rutland Hollow valley for example), may be the cumulative effect of multiple advances and recessions of the ice sheets.

The three broad elements in the history are: (1) the larger features of the land relief (described above), or the topographic control over the ice movement and the water flow; (2) the waning ice body on the north, acting as a receding dam and holding the imprisoned waters up to certain outlets of escape; (3) the impounded waters finding lower and lower escape in different directions, as shown by the outlet channels and the lake plains.

The glacial waters of the Black valley had four main stages, determined by four principal directions of escape. The first and highest stage was that of waters not limited to the Black valley but extending into the Mohawk area and controlled by outlets from the latter. The second stage had overflow to the southeast, through Remsen into the waters held in the Mohawk valley, the altitude of the channel heads being 1240 feet. The third outflow was at Boonville to the southwest, cutting the Lansing kill gorge, with ultimate escape to the Mohawk valley. The fourth and less simple stage was controlled by westward escape around the north end of the great ridge which separates the Black valley from the east end of the Ontario basin, comprising water levels from 1200 down to the Lake Iroquois plane, about 735 feet in the Carthage-Watertown district. The complete history must include the Iroquois waters, which flooded the lower end of the Black valley.

FIRST STAGE: MOHAWK WATERS; HERKIMER LAKE

There seems to have been a stage in the waning of the ice sheet when the Ontarian lobe, pushing east over the district of Oneida lake and Rome, thrust its front, with a northwest-southeast trend, against the foothills of the southwest flank of the Adirondacks.

View on Alder creek moraine

One and one-half miles southeast of Alder creek. Looking west. A characteristic scene.

The map, plate 2, shows this frontal moraine which was built along the ice margin, extending from Boonville southeast across the map.

While the ice was building this moraine the high-level waters which occupied a section of the Mohawk valley flooded the ground in front of the ice. The heavy drainage from the mountains brought down an enormous volume of detritus into the shallow waters fronting the glacier and built the extensive sand plains in the region of Forestport, having an altitude from 1440 feet down, and which apparently entirely filled the lake in that district. These delta deposits are described later (page 12).

This lake was held between the Ontarian and Hudsonian ice lobes and is believed to have outflowed through the Otisco and Unadilla valleys to Susquehanna drainage. It is described later in this paper (see page 19). The waters fell by the ice recession opening lower outlets in the Schenectady region, and the lowering was probably going on while the ice front in the Forestport-Remsen district was receding. At length the water surface fell below the divide or water-parting which bounds the Black river hydrographic area and the Black waters were differentiated as a distinct lake.

SECOND STAGE: FORESTPORT LAKE; REMSEN OUTLET

The first outflow of the distinctive Black waters was across the moraine, forming the divide, north of Remsen, and then south through the depression in which Remsen is located. The river reached standing waters and built deltas four miles south of Remsen, at Trenton and Trenton Falls. These features are shown in plate 2.

The Forestport lake with its overflow by Remsen must have persisted until the ice front had receded southwestward halfway to Rome, or to the west flanks of Quaker and South hills through a distance of over 10 miles, so as to open the Lansing kill outlet. The altitude of the lake surface was about 1240 feet during its closing phase. The altitude at the inception of the lake was as much above 1240 as was the amount of downcutting of the Remsen outlet, which was no more than perhaps 20 or 40 feet. It could not have been as much as 80 feet, as the next highest col, three miles northeast of Remsen with map altitude 1320 feet, is uncut by stream flow. We do not know where the early overflow and cutting occurred and we have no check in delta heights in the lake area, as these lie at various heights, this lake being merely the successor of the higher Mohawk waters.

The Forestport waters were shallow and the boundaries very

irregular. The abundant detritus brought into the shallow lake by the copious drainage from the southwestern Adirondacks, through the upper Black river and neighboring creeks, seems to have quite completely filled the lake, producing the broad delta plains described below.

The Remsen outlet heads in several indefinite passes among morainal knolls in the stretch four or five miles north from Remsen. By the topographic map the present altitude of these swamp cols is 1240 feet. About one mile north of Remsen the winding swampy channels unite into a single definite rock channel which continues for three miles south of Remsen and ends in terraces and scourways on the delta north of Trenton and Trenton Falls villages. The head of the rock channel north of Remsen is 1200 feet altitude. In the south edge of the village it rapidly falls to 1100 feet and in another mile it drops to 1000 feet. The fall of 200 feet in two miles gave the Remsen river a torrential character, the evidences of which are seen in the eroded limestones with abandoned cascades. These features may be well seen on the east and west road somewhat over a mile south of the village.

The flow of the distributaries over the delta northeast of Trenton and north of Trenton Falls is conspicuously shown by terraces and channels. These benchings, found specially on the slopes facing north and west, indicate that the receiving waters occupying the Mohawk valley were slowly falling during the life of the river. It also appears that the Remsen river ceased its flow while the Mohawk water was standing with an altitude of about 980 feet, the height of the lowest well-developed plains.

Forestport sand plains. The delta plains built in the Forestport and higher lakes by the tributary drainage are very extensive, covering nearly all the area for several miles north, east and southeast of the village, and must have quite filled the shallow waters. Superficially they are mostly sand and were derived from the wastage of the quartzose rocks of the Adirondack crystallines. These sand deposits were laid down over the ice-laid or moraine deposits, which in places project up through the lake beds. This is strikingly illustrated in the lofty kame hills, the most conspicuous heights of the district. The village of Forestport lies on the west side of a large kame hill. Another mass lies one and one-half miles south of the village, and a very prominent pair of steep sand hills about three miles northeast, locally called Dustin hills, rise 140 feet above the broad expanse of level sands. The ice block kettles which are such

Stony content of the till

Excavation one mile northwest of Alder creek. Looking southeast. The rejected material shows the stony character of the ice-laid drift in the Alder creek moraine.

a prominent feature of the Port Leyden quadrangle (see page 15) are wanting in the Forestport sand plains.

These sand plains seem to have been built against or near the ice margin, and the materials are theoretically of triple origin: largely detritus brought in by the Adirondack drainage; partly contributed by streams pouring out of the melting glacier; and partly derived from the wave erosion of the kames and glacial deposits.

The Forestport sand plains lie in a series of sloping terraces, declining westward. Five miles northeast of Forestport, on the north edge of the Remsen sheet, the highest plain is 1400 feet, though there are evidences of wavework still higher. Other terraces or benches of the district are found at all levels down to 1140, the terrace on which the village stands. Near Enos, six miles southeast of Forestport, are sand plains at 1420 down to 1360 feet. The levels above 1300 feet must certainly belong to the first stage, or Mohawk waters, while those below 1200 feet as certainly belong to the next and lower stage, Port Leyden lake. It will not be possible to correlate all the terraces with definite attitudes of the waters, and the tilting of the land complicates the study. But this fact is brought out clearly, that the sand plains were spread out in slowly subsiding waters and were extended westward at lower and lower levels as the ice front receded.

On the map (plate 2) the delta plains credited to the several lake stages are indicated by different shadings ("conventions") and the limits can not be exact. The altitudes of the upper and lower limits of the Forestport lake deposits are taken as about 1280 and 1200 feet. As a rule the shadings are restricted to terrace limits, but it is possible that some higher portions of sand plains marked as Forestport may belong to the earlier Herkimer lake, or that some of the lower parts may be deposits of the subsequent Port Leyden waters. However, in a general way the map must indicate the true relations.

These plains have been noted by W. J. Miller (see title 27, pages 42–45).

In the maps showing the waning of the ice sheet the Forestport lake is not indicated, but it belongs to a phase between those of plates 13 and 14.

THIRD STAGE: PORT LEYDEN LAKE; BOONVILLE OUTLET

This lake is the one of longest duration in the life of the Black valley glacial waters. Its outlet was the narrow, deep gorge of the present Lansing kill, extending from Boonville south some 10 miles

to the Mohawk river at Northwestern. The history of the lake is graphically indicated in plates 15 and 16 and the central part of the basin is shown in plate 3. The lake was narrow at the south end, being about two miles wide at Port Leyden, three miles at Lyons Falls, five miles at Glenfield and expanding northward. The west shore of the lake was quite direct, lying along the limestone slope, but the east shore was very irregular, being formed by the enlarging deltas built by the Adirondack drainage. The depth of the lake was about 260 feet at Port Leyden, 300 feet at Lyons Falls and 400 feet at Glenfield.

The outlet valley is a narrow, deep channel in shale, evidently cut by a vigorous stream of relatively short life, and well shown in plate 2. It does not appear just where the initial overflow began, but we know that it could not have been higher than 1240 feet, the altitude of the deserted Remsen outlet. Before the Lansing kill valley became the outlet of Black waters it must have been flooded by the Forestport lake, until the ice front receded from the Steuben valley between Trenton and Northwestern (see page 35). The ultimate head of the glacial river and the present col is a flat stretch extending southeastward from Boonville about two miles and now occupied by the summit level of the Black river canal. This has one lock (no. 71) in Boonville and the next (no. 70) over two miles south, the water surface being 1120 feet. About one and one-half miles south of the village the canal has a cut of 10 feet in limestone, which makes the present altitude of the outlet channel about 1130 feet. Immediately below the head of the channel the river had cascades, the widened main channel having narrow and steep trenches on both sides, with a plunge basin and lakelet on the east side.

One mile below the cascades the channel becomes very narrow, in shale, with only room for the present creek, the highway and the canal, and so continues for six miles. The succeeding five miles to Northwestern have a somewhat wider but yet narrow valley, and from that village the valley is open, preglacial, and partly filled with detritus. Below the village of Delta the ancient valley was blocked with moraine and the present Mohawk has been compelled to cut a channel on the east side of the old valley, locally known as the "Palisades." Delta village lies on the old lake bottom and present Mohawk flood plain.

From the channel head two miles below Boonville, to Northwestern, a distance of about 11 miles, the channel bottom drops 530 feet (from 1130 to 600), the canal having in that stretch 48 locks.

Sandplains in Black valley

A view of the bold front of the plain, as seen looking east across the Black valley from a point two miles east of Talcottville.

Kettle in Delta plain

Four miles northeast of Lyons Falls. Looking northwest from road. A small sample of the numerous basins in the sand plains.

The deltas built by the Boonville river in the falling Mohawk lakes will be discussed later (see pages 35).

The sharp hills about Boonville are kame-moraine and similar to those previously noted in the Forestport district. Sperry hill northeast of the village rises 280 feet over the village, or to 1400 feet. At present the canal is chiefly used for carrying sand from these hills to Utica and eastward cities.

Sand plains in Port Leyden lake. The east shore of this lake received an enormous supply of detritus. The deltas are developed on a magnificent scale and form a practically continuous sand plain along the east side of the valley, as shown in plates 3; 20 and 21. The plain is trenched by the Black river tributaries and broken by numerous deep, irregular basins or kettles produced by the melting of blocks of ice which had become detached from the waning glacier and surrounded, or sometimes wholly buried, by the delta sands. These ice block kettles probably surpass in size, number and excellent character any other district in the State.[1] (See plate 21.)

Some of the higher sand areas along the east edge of the Port Leyden quadrangle and eastward may perhaps have genetic relationship to local waters held along the ice margin, or possibly even held between the Black valley ice lobe and alpine glaciers from the Adirondacks, but the broad, smooth plains indicated on the map must certainly correlate with the Boonville outlet. About Bucks Corners the sand plain abuts against moraine at 1220 feet. Northeast of Port Leyden the good delta plain is 1215 to 1220; south of Brantingham it is up to 1225 to 1230 feet. Above these levels the plain becomes duny, rolling and irregular. Beyond the upper limits of the plains dune knolls are common. The northward rise of the sand plains on the Port Leyden sheet averages about five feet per mile, and as they are thought to have been deposited at about the same time this slope may be taken as the amount of the deformation.

The depth of the lake deposits must be great, as the kettles, except a few at the north edge of the map, do not hold water, though some of them are over 60 feet deep; and rock or till rarely appear except in the deeper stream cuttings. Some of the kettles show cobbly kame gravels and boulders on their walls.

The sand plains are now destitute of forest and occupied by grass and scrubby growth of scattering trees.

---

[1]A good example of a large kettle in a small delta in central New York is described in Jour. Geol. 6:589.

FOURTH STAGE: GLENFIELD LAKE; COPENHAGEN-CHAMPION OUTLETS

The remarkable series of west-leading channels shown in plate 4 are the outlets of this water.

This lake did not have a permanent level but a series of falling levels as new outlets were opened on the north-facing slopes southwest of Carthage. The primitive and highest level was something over 1200 feet, the present altitude of the bottom of the highest channel, a mile northwest of Copenhagen. The lowest level was a blending into the waters of Lake Iroquois at about 740 feet. The lowest scourways seem to lie through West Carthage, a well-defined channel west of the village being 760 feet.

At the beginning of this stage the waters extended up the valley to Boonville, but the area diminished as the surface fell by the opening of successively lower outlets until only the lower or northern part of the valley was flooded, probably only the stretch from Carthage to Glenfield. This stage is called the Glenfield, as that village is the most northerly in the axis of the valley.

The northern part of the eastern shore of the lake is on territory not yet mapped, being the quadrangle east of the Carthage and north of the Port Leyden (Lowville sheet).

The curving course of the outlet channels shows how the ice front curved about the higher ground and deployed on the low ground, thus forcing the drainage against the convex slope. The earliest flow must have passed along the ice front east of Adams and finally reached the primitive Iroquois waters farther south, perhaps at Sand Bank or Williamstown, or possibly as far as Camden. All the subsequent drainage found its base level in Lake Iroquois at Adams, where an extensive delta was built, with altitude 620 to 630 feet and fronted by the Iroquois beach. The higher channels were cut in Lorraine shales, the lower in limestones.

When the ice front lay higher on the land slope there must have been a similar drainage past the ice margin of the local waters and such channels of the earlier time are indicated on the map, east and southeast of Adams, in the towns of Rodman and Lorraine, lying along the general slope with a southward direction. This local drainage probably ultimately reached the early Iroquois farther south; but the local drainage of a still earlier time must have followed along the ice margin until it reached the Mohawk waters in the vicinity of Rome (see page 34). No attempt is here made to fully map the high-level ice-border drainage, it being represented on plate 4 only where casually found. However, the cross-ridge

Glacial stream channel

One mile north of Champion and four miles west of Carthage. Looking south, upstream.

channels, from valley to valley, and parallel with the general land slope, must occur over the west-facing and south-facing slope of the high ground as far as to the Rome district.

Deltas in Glenfield lake. During the previous stage a small lake had been held in the valley of Deer river, along the summit of the great ridge between the Black and Ontario valleys. The escape of the Deer lake must have been westward through a summit swamp, north of New Boston at about 1530 feet, into the ice-border drainage noted above. One channel seems to lie through Barnes Corners. When the ice barrier receded to the vicinity of Harrisburg the Deer lake escaped eastward and so continued by a series of small but distinct channels at falling levels until the Deer lake was drained. These outlets of Deer lake built a delta of conspicuous size on the west shore of the Black waters near Harrisburg, and five miles northwest of Lowville. Other deltas occur where the Deer river dropped its detritus in the falling Glenfield lake below High Falls and at Kings Falls. The reader should observe that the Deer lake outlets are the only east-leading channels on plate 4.

FIFTH STAGE: LAKE IROQUOIS

When the ice front receded from the promontory lying between Watertown and Carthage the distinctive Black valley waters ceased to exist and the Carthage district was occupied by the waters of the great Lake Iroquois. The Iroquois beaches are found in conspicuous form on the steep slope northeast of Watertown, at 733 feet. Eastward toward Champion Huddle and Carthage the shore line features are fragmentary, but the altitude is taken as 740 to 750 feet. The plain of the Black river above Carthage is now 730 to 740 feet, and the Iroquois waters at first probably extended some miles up the valley, but soon filled with the river silt, becoming a swamp. The real delta of the Black river in Lake Iroquois is the very extensive sand plain heading northwest of Carthage forming the " Pine Plains," which extend to Black River, Felts Mills and Leraysville. The head of the plain is about 735 feet, declining to 520 at Leraysville.

Until the quadrangle north of Carthage is mapped the Iroquois features of the region can not be satisfactorily described.

PREWISCONSIN TOPOGRAPHY

The tract of country covered by the heavy channels in plate 4 exhibits many scarps, terraces and hollows which antedated the river flow under discussion. Some of these are comparable to the

scarps and benches shown in plate 3 on the west side of the Black valley. These features may be certainly attributed in part to the millions of years of weathering and stream work before there was any ice invasion. But the peculiar shaping was done in part by the eroding action of the ice sheets, and specially by the forced glacial drainage of ice sheets previous to the Wisconsin.

A good example of these anomalous features is the Rutland hollow and hill east of Watertown. Here is a capacious valley behind an isolated rock mass, both having northeast by southwest direction, transverse to the general land slope and normal drainage but consonant with the ice blockade and ice-border drainage. It seems quite certain that any earlier ice invasion must have produced, both in advance and retreat, lakes and drainage somewhat similar to those here described. The accumulating evidence of more than one glacial epoch in New York adds force to the thought that some of the peculiar relief features of the region have been produced by multiplicity of glaciation and glacial drainage. The lowland of St Lawrence valley and east of Lake Ontario exhibits many anomalous features which harmonize with this view.

Stream deposits in Lake Iroquois

East Watertown, mouth of Rutland hollow. Looking southeast. At the left is seen a mass of bouldery till enclosed in the sand beds.

MOHAWK VALLEY GLACIAL WATERS

FIRST STAGE: EARLY ADIRONDACK DRAINAGE

In describing the outflow of the Black valley waters reference was made (page 12) to deltas built at Trenton by the Remsen river and north of Rome by the upper Mohawk. These deltas are too massive to represent local and transient lakes held in embayments along the edge of the glacier, and their position and relation to the ice front and to the open valley forbid the assumption. The ice front here was a lobe pushing in from the west. The deltas lie on the north border of the broad Mohawk valley and were evidently deposited in broad waters which flooded the Mohawk and extended far east. The existence of other high-level lake deposits in the Mohawk valley has long been known, terraces and level stretches being conspicuous at intervals from Utica to Schenectady. The waters were ice-dammed. The Hudson valley ice lobe blocked the valley on the east while the Ontario ice lobe blocked it on the west. With the knowledge already gained concerning the positions of the receding ice fronts, the impounded waters and the inclosing topography, the conclusion is imperative not only that the Mohawk valley held glacial waters but that they were sustained at different levels.

In the waning and thinning of the ice sheet which overspread central and northern New York there must have been a stage when only a neck or strait of ice rested in the Mohawk valley, connecting the Hudsonian and Ontarian lobes of the Laurentian glacier. The earliest glacial waters of the Adirondack region must have gathered in the valleys along the southern slopes of the highlands and resting against the margin of the ice in the Mohawk valley. The only escape for these waters was southward across the Mohawk ice at its lowest point (see discussion of this matter in the introduction). The sand plains in the Adirondacks at high levels probably belong to this time. Some of the water deposits were probably accumulated in restricted waters, held by local glaciers or by tongues of the receding ice sheet which surrounded the exposed highlands; but the ultimate escape of the waters must have been to the south and over the belt of stagnant ice which lay in the Utica-Little Falls section of the valley.

The early removal of the ice sheet from the Adirondack highlands and the consequent existence of high-level glacial waters in the mountain district has been recognized by F. B. Taylor (see title 36). He noted terraces and sand plains in the Saranac valley at 1370

feet, and other water planes at 1400 to 1600 feet. For these waters he proposed the name Lake Adirondack.

As these waters must have been extremely disconnected, lying at different levels about the margin of the exposed highlands, and tributary to those on the south side with ultimate escape across the ice strait in the Mohawk valley, the writer hesitates to call them by a name implying a distinct lake. However, the name Adirondack waters holds both by priority and appropriateness.

The existence of standing waters in the larger Adirondack valleys has also been recognized by I. H. Ogilvie (see title 29), but no altitudes are given.

It is not possible now to locate with absolute confidence the point or points of outflow, or the valley south of the divide which carried southward the glacial waters. It was not necessarily by the stream which today has the lowest col on the divide between Mohawk and Susquehanna drainage, and there might have been more than one point of escape.

The col at Cassville and Richfield Junction (Delaware, Lackawanna & Western Railroad) 10 miles south of Utica, has a combination of characters that are suggestive in this connection (see plate 5). Here is a smoothed col, over a mile wide, heading at about 1260 feet the wide, smooth valley at North Bridgewater now drained by the west branch of the Unadilla river. A broad sand plain north of the railroad junction has the altitude of the col and indicates standing water north of the divide. A kame-moraine area north and west suggest a long stand of the ice margin at this place with heavy outwash. This pass could not have been the outlet of widespread or open Mohawk waters as the Cedarville pass, six miles southeast, is 40 feet lower. The writer has supposed (see title 17, page 20) that the glacial waters of the Sauquoit valley were responsible for the characters of this pass, but they hardly seem competent. The pass at Bouckville, the head of the Oriskany valley at 1150, is also suggestive, but it lies far west. Another pass which certainly carried a flood of water is the col at the head of the Otsego-Susquehanna valley with altitude 1360 (described page 23). If this outlet did not carry the earliest flow from the Adirondacks across the ice strait it certainly did carry glacial waters before the Cedarville pass was opened. It has also the location opposite what would seem to have been the weakest section of the waning ice strait.

The ice in the valley may have been so heavily burdened with rock rubbish that submergence could not lift it, but the waters must have

aided the melting, and eventually a section of the valley was free of ice and held only the earliest of the Mohawk glacial lakes.

We have some facts which bear on the matter of the location of the weakest section of the Mohawk ice strait. The existence of drumlinlike forms on the south side of the valley and with east and west direction has been recognized since the publication of the Utica and Richfield Springs sheets. In 1908 Professor Brigham described west-pointing drumlins in the Johnstown region (see title 6, page 25). In the autumn of the same year the writer determined that drumlins indicating a westward flow of ice exist in perfect form in the district northeast and northwest of Richfield Springs, but that they terminate east of the Utica meridian. The ice-molded drift forms a restricted area, mostly on and south of the line of divide, about eight miles wide beginning north of Otsego lake and stretching northwest to beyond Cedarville, a distance of about 18 miles. The drumlins are partially indicated on plate 5.

It has been shown that drumlins are a product of the sliding movement of the thinning ice edge when under efficient thrustal motion of thick ice in the rear.[1] The Richfield Springs drumlins were produced by the movement of the thinner ice on the high ground, under the push of the thicker ice in the valley eastward. The more remote pressure was, of course, from the Hudson valley lobe. The drumlin-forming ice was an overflow from the valley ice tongue.

Here we have evidence of ice flow up the valley, from the Hudsonian lobe; and we have proof that for a long time subsequent the Ontarian lobe lay over the Rome district. The westward flow of the Mohawk valley ice was, at this phase, probably met by the opposing Ontarian ice somewhere in the Little Falls-Utica district. The locality of the meeting between the two ice tongues, in the later phase, would probably be the place of subsequent separation.

The question is now pertinent: Why did the Hudson ice push so far westward up the Mohawk valley, meeting the Ontario glacier much more than half way, while at a later time the Ontarian lobe lingered over Rome, at the west end of the valley, when the Hudson valley in the Schenectady district was clear of ice? The explanation seems to lie in the form and the relative altitude and cross section of the St Lawrence and the Champlain-Hudson valleys. When the ice body was thick over both the Champlain-Hudson and the St

[1] Drumlins of Central Western New York. N. Y. State Mus. Bul. 111, p. 429.

Lawrence-Ontario the former dominated in the Mohawk region, for the reason that the course was more direct and the distance less. But as the ice body thinned this advantage was overbalanced by the narrower and more restricted cross section of the Champlain valley as compared with the open, though somewhat higher St Lawrence.

At the time of the ice retreat the north boundary of the State was depressed at least 600 feet below its present altitude and the entire Mohawk area was lower than now and probably somewhat lower relatively to central New York.

SECOND STAGE: HERKIMER LAKE

The sketch map, plate 1, shows the southern limits of the Mohawk drainage, including the Schoharie valley. The passes across the divide which bear evidence of stream flow are also indicated.

The first step in the study of the glacial lake history is to determine the altitudes of the water planes and to find the points of overflow or the correlating outlets, keeping in mind the fact of some later northward uplift. It was discovered that very extensive sand plains north and east of Forestport and near the hamlets of Grant, Gray and Ohio, in the basins of the upper Black river and of West Canada creek, had an elevation of 1440 feet, while other extensive plains ranged in the neighborhood of 1300 feet. Examination of the passes leading out of the Mohawk basin shows a strong river-cut channel in limestone at the head of the Otsego valley and seven miles east of Richfield Springs, with an altitude of about 1360 feet. Another capacious channel of perfect form lies at Cedarville, eight miles northwest of Richfield Springs, at the head of the Unadilla-Susquehanna, with an elevation of 1220 feet. Farther west is only one pass with lower altitude than the Cedarville, at Bouckville, four miles north of Hamilton, leading to the Chenango river, with an elevation of 1150 feet. Passes at Richfield Junction and at Sangerfield have elevations of 1260 and 1240 feet. All these features are shown on the Richfield Springs, Winfield, Sangerfield and Morrisville sheets, and the two passes first named are shown on plate 5. The passes on the east can have no relation to the Ohio water planes, being either too high or too low, with the exception of one four miles south of Middleburg in the Schoharie valley, at the head of the Catskill creek, with elevation 1200 feet. Examination of this col shows a tiny stream cutting across the summit but incapable of carrying a respectable creek; and the flow there was probably northward.

Taking the several elements of the problem into consideration the only pass leading out of the Mohawk basin which correlates with the widespread sand plains having an altitude of 1400 feet and upwards is the one at the head of the Otsego valley, between Springfield Center and Summit lake. A northward uplift of about two feet per mile brings this channel, 1360 feet, into close accord with the high sand plains at Forestport, Grant, Gray, Ohio and Devereaux-Stratford.

The Summit lake channel is in limestone. The map makes the divide a mile north of the lake but the cut channel is at and south of the lake. Going north from Springfield Center singular heaps and knolls of limestone rubbish are seen, which are clearly piled by plunging or cascading waters. Beyond these the channel is bare limestone in ridges and hollows with lateral recesses and terraces. North of the lake and swamp are moraine knolls at the head of the pass, at about the altitude of the lake. The aneroid and hand level made the stream-cut limestone ridges south of the lake somewhat higher than the lake. It would seem that the original rock divide must have been in the limestone south of the lake.

The morainal surface at the head of the pass and the irregular bed in the eroded limestone indicate that the river did not have length of life sufficient to level or smooth the channel entirely across the col. The head of the pass may have been ice-obstructed; and it is possible that the flow in this pass was directly from across the strait of ice which filled the valley on the north. This seems the probable locality where the early ice-bound waters, held about the exposed foothills of the Adirondacks, would find ultimate escape.

No clear separation can now be made between the Adirondack waters which were drained across the ice and the early lake in the ice-free section of the valley. As most of the features described in this chapter lie in the area of Herkimer county the name Herkimer lake may be properly given to the waters, without close discrimination as to altitude and outflow.[1]

The Summit lake channel correlates with the 1400–1440 feet sand plains, the difference of 80 feet giving the theoretical uplift of two feet per mile, with some allowance for depth of the river and downcutting of the outlet. In the same way the Cedarville channel, 1220

[1] The sand plains at Forestport are in Oneida county; part of those at Devereaux-Stratford are in Fulton county; and the Summit lake outlet is just over the line in Otsego county. The Cedarville channel, which was the outlet of the positively open-valley water, is in Herkimer county.

feet, correlates with the sand plains at or near 1300 feet. The latter are well developed contiguous to the higher plains, and represent the lower level of the Herkimer lake.

With the opening of the Cedarville channel the Herkimer waters fell about 100 feet. The amount of downcutting is not evident, but the present channel is 140 feet lower than the Summit lake channel.

The Cedarville channel was located theoretically in advance, simply from the map.[1] Its excellent character even surpassed expectation. It is a handsome and typical river channel of mature form. It is at least one-fourth of a mile wide; steep banks, uniform width and grade, with the long stretch of level summit occupied by a swamp of cedar which has given name to the village. The valley below the col, through East Winfield, West Winfield and Unadilla Forks, has the characters produced by a strong river with low gradient.

It is possible that the Ontarian ice lobe backed away along the southern divide sufficiently to allow the Herkimer waters to find escape by the Bouckville pass, at 1150 feet, but it is not probable. A high ridge between the Unadilla and Sangerfield rivers extends north nearly to the parallel of Clinton, ending in Crow hill, six miles southwest of Utica. The ice lobe in the Utica district probably pressed against this salient to the close of Herkimer time.[2]

The Cedarville channel is believed to have been the final outlet of the Herkimer lake, and to have persisted all the time required for the ice lobe in the Hudson valley to recede sufficiently to open a lower pass in Albany county, initiating the next stage.

The extent of the Herkimer sand plains is suggested by plates 2 and 7, where they are shown ranging from 1440 down to 1280 feet. They will be found in many districts, either where heavy streams poured into the lake or where there was outwash from the glaciers. The differential uplift must be taken into account, which may not be uniform far to the north. They should be found in large development through the Adirondacks, but will not occur in strength on

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[1] The certain proof of the correctness of the glacial lake philosophy is found in the fact that nearly all the more important glacial stream channels in the State, described by the writer, have been located in advance of any visit, by the study of the topography in relation to the position of the ice front.

[2] The writer has described certain west-leading channels at Crow hill (see title 17, page 22), but they are regarded as having carried only the small volume of water from the Sauquoit valley on the east over into the Oriskany valley and Bouckville escape.

EDUCATION DEPARTMENT
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STATE MUSEUM

BULLETIN 160 PLATE 7

74°45′ 74°40′

Knapp Reservoir
Knappville
North Cr.
Story Brook
Hammel Creek
East Canada Creek
Oak Mt.
Bear Hill
Devereaux B.M.
Stratford
Ayers Cr.
East Boundary Line
Emmonsburg
Moose Creek
HERKIMER CO
FULTON CO
Zoller Brook
Lotville

43° 10′

GLACIAL WATERS
IN THE
MOHAWK VALLEY
H. L. FAIRCHILD
1909

LEGEND

DELTAS OR SANDPLAINS

Herkimer lake

Schoharie lake

INTERPRETATION

COMPARE MAPS, PLATES 13-14

These deltas were built in the Mohawk waters by East Canada creek. Only the more prominent levels are indicated. The area in general is very bouldery moraine.

74°45′ 74°40′

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 20 feet.

Datum is mean sea level.

the south side of the Mohawk valley as the streams there are relatively short and weak, the slope steep and the strata chiefly shale.

Toward the close of the stage the Herkimer waters probably extended from Utica to Johnstown. Its precise limits are unknown. Plate 13 gives suggestion of an early phase.

The evidences of standing water at high levels throughout the Mohawk basin are abundant and conclusive. Above about 1200 feet the features are chiefly the extensive sand plains by the northern drainage, but below that level the proofs are more varied and very common. Delta plains usually occur, at falling levels, along the stronger streams and in hundreds of localities where the detritus was not so abundant as to produce definite and conspicuous plains we find silted hollows and sandy stretches.

Below about 1200 feet the valley walls exhibit the peculiar smoothness or softness of outline characteristic of wave-washed slopes. Distinct beach lines are not uncommon and in some localities the horizontal marking of the slopes due to wave erosion are striking. They are specially conspicuous in the Little Falls district where the soft Utica shale of the valley walls combine with other factors to favor their production. Some of these beach lines require for visibility a viewpoint of proper altitude and a suitable lighting.

The best example noted by the writer of the high-level beach lines lies on the south side of the valley four miles southwest of Little Falls, and may be clearly seen from the New York Central and the electric railroads in all lights, but are specially prominent with a sunset lighting. They are shown in the accompanying figure and in plate 25.

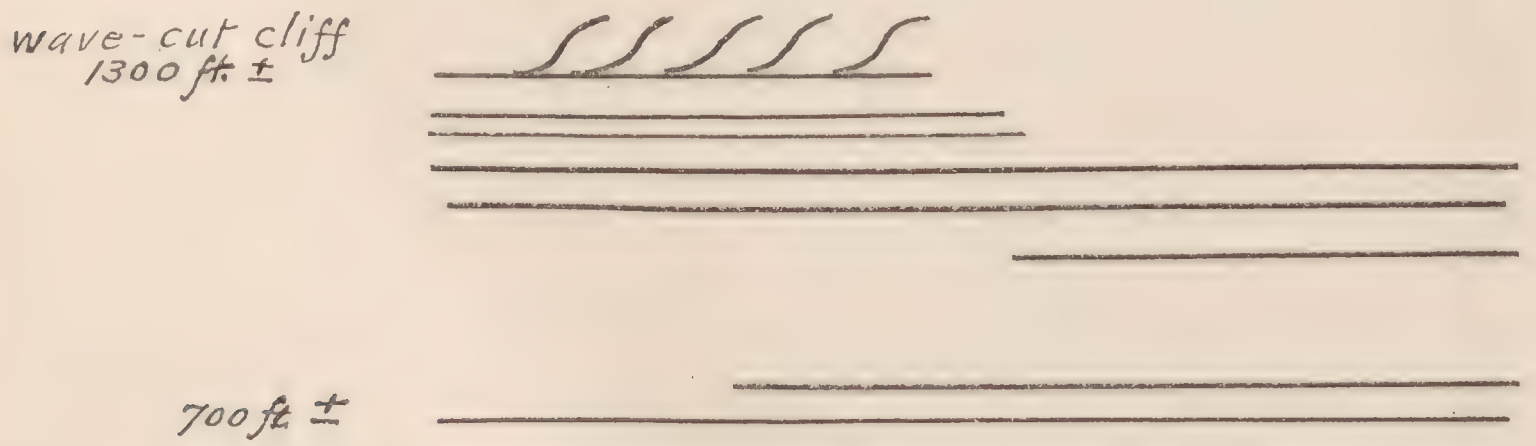

Figure 1 Sketch of beach lines produced by high-level waters in Mohawk valley, four miles southwest of Little Falls. View from river bank two miles southwest of village. Compare plate 25.

In a former paper these horizontal lines were attributed to stream work of ice-border drainage, but it is now found that they are the product of lake waters. The highest wave-work that is evident on the ground is at about 1300 feet, a cliff and terrace at the foot of

the summit knoll which was the site of the triangulation station (1372 feet). A farm house stands on the terrace by the highway which traverses the wave-cut hillside. The highest beach line of the series, shown in plate 25, is at about 1200 feet, and the lowest is at about 700 feet.

Similar conspicuous beach lines occur on the north side of the large valley, and also on both sides of the lateral valley leading southeast toward Newville. It would seem that the northwest winds were able here to produce wave and current work that was effective in carving the soft shales. Other examples of wave action occur east of Little Falls but require for clearness a higher viewpoint than the railroads.

Conspicuous shore lines lie on Sperry and Park hills east of Boonville, in the neighborhood of 1200 feet.

With recognition of their nature these beach lines will be found in many localities throughout the areas of the Herkimer and the lower lakes.

THIRD STAGE: SCHOHARIE LAKE

The only large valley opening into the Mohawk from the south is the Schoharie. The river rises in the heart of the high Catskills, the three headwater cols having, by the map, 1920 feet altitude. A glance at the map, plate 1, will show how the attitude of the valley, declining northward toward the receding ice barrier, fulfilled the primary condition for a glacial lake. The valley must have held glacial waters at different levels. Some of the passes at the head of the valley might have been blocked by local or alpine glaciers during the earliest phase, but one or more of them must have been the outlet for the primitive lake. Later the narrow gorge across the west divide at 1560 feet must have become effective. From the map it would appear that the next successive outlet would be the 1200 feet pass on the east divide, four miles southeast of Middleburg, at the head of the Catskill creek. However, that does not seem to have been the order of events. The Middleburg pass never carried a large stream, and the small flow which did occur was probably northward into the Schoharie waters. This somewhat surprising fact is explained by two factors in the problem, first the postglacial deformation, and second, the larger topographic relation of the valley to the Hudson and Mohawk valleys. The Middleburg col is 25 miles south of the parallel of the Cedarville channel. If the northward uptilting of the land involved the Schoharie valley, the two feet per mile of tilt would make the Cedarville pass 30 feet

Cobble heaps on Delta tract

One mile southwest of Delta. Looking south from highway. Note the subuniform size and rounded forms. A characteristic view on the delta plains.

Beach lines in Mohawk valley

Wave-work of lake waters, south side of Mohawk valley, four miles southwest of Little Falls. Mohawk river in foreground.

below the Middleburg, while half that slope would still keep the Middleburg plane superior. The second factor involves the ice barrier. During the earlier phases of the Schoharie lake history, when the Middleburg pass might otherwise have been effective, the Hudson valley ice tongue probably lay against the Catskill highland, west of Catskill village, at so high a level as to block outflow of the Schoharie-Mohawk waters by the Catskill valley. Later, when the ice was removed from the Catskill scarp the Cedarville outlet was probably open at an inferior level. Detailed study of the deltas built in the Schoharie valley by side streams will probably show a strong lake plane somewhat beneath the Middleburg pass, the latest phase of the Herkimer lake.

Professor Brigham has noted lake deposits in the Schoharie valley above Esperance and in the tributary Cobleskill valley, which he attributed to a morainal dam near Burtonsville, and he called the waters the Schoharie lake. The present writing would make the name include all the glacial waters which, extending through both the Schoharie and Mohawk valleys, had their escape across the east divide of the Schoharie basin. Local names may be desirable for any distinct phases of these waters.

Schoharie lake outlets. The first downdraining of the Herkimer lake and the initiation of the Schoharie came when the Hudsonian ice lobe, lying against the Helderberg scarp west of Albany, weakened so as to permit outflow across the east divide of the Schoharie valley.

The earliest outflow of the Schoharie waters was probably along the face of the Helderberg scarp, crowded between it and the glacier. Plate 6 indicates the channels along the face of Countryman hill and southward, specially under 1100 feet. The writer has not made close study of the district but sufficient to show that the saliences of the great scarp west of New Salem up to about 1200 feet have been scraped by powerful water currents. The map shows the southward continuation of these rivers, alongside the glacier, and parallel to the wall of the Hudson valley. Apart from any ponding of waters in the Mohawk basin such ice-border drainage was a positive necessity; but with the contribution of the Adirondack-Mohawk drainage added to the copious waters from the glacier melting there was a heavy concentration of flow along the margin of the ice tongue, seeking southward escape. The continuation of these channels far to the south is apparent on the topographic sheets.

It must not be thought that the Wisconsin glacial drainage is entirely responsible for these channels (transverse to the normal

direction of the land drainage of the valley wall). They were made by stream-flow and ice-wear of probably more than one earlier glacial epoch, and certainly were occupied by the lateral drainage during the advance of the last ice as well as during its recession. The glacial rivers which we are considering only finished a work partly done long before.

The ice body in the Hudson valley lying over Albany and Schenectady must have pressed against the Helderberg scarp for a long period. The hypothetical relation of the ice lobe to the land configuration is suggested in the maps, plates 14, 15.

There are two passes across the divide, in Albany county, between the Schoharie and Hudson valleys which are inferior in altitude to the Cedarville outlet, but only the lower one was effective as a river channel. The col at Knox, five miles southwest of Altamont, at 1160 feet, is uncut and no evidences of stream work are found on the slopes of the valley. It appears that during the earlier and higher outflow of the Schoharie waters along the face of the Helderberg scarp the Knox and Delanson passes were submerged in the lake waters. Eventually the lake was lowered so that flow occurred through the Delanson pass; and when the Schoharie waters were finally drained down to about 900 feet the Delanson river was established. The present altitude of the channel, two miles west of Delanson, is 840 feet.

This channel is a good example of an abandoned stream bed, though not nearly so capacious and mature as the Cedarville. The outflow was reduced in volume because the ice was out of the Mohawk basin and the supply of water from the melting glacier was greatly diminished. The life of the river may not have been long, as a still lower escape was to be opened northwest of Schenectady. The earliest flow through the Delanson channel was forced southeast through the valley of the Boxen kill and the site of Altamont.

The area of the Schoharie waters was probably the whole basin of the Mohawk and its tributaries east of Utica and all of the Sacandaga valley that was free of ice. The height of the water on the Little Falls parallel began at about 1200 feet and fell to about 880 feet. On the parallel of Schoharie and Cobleskill the waterplanes will range from 1150 down to 830 feet (see plate 14).

No exhaustive study has been made of the planes and deltas of this stage, but sand plains have been noted in far-separated localities, some of which are indicated in plates 2, 7 and 8. The following delta plains are regarded as correlating with the Knox-Delanson

outflow: the upper plains at Prospect and Trenton Falls (1160–980); the lower at Devereaux-Stratford (1160–1000); the higher at Northville-Edinburg (1040–940); the lower at Poland (940–820); and the terraces in the Lansing kill valley and the upper Mohawk at 1200 to 920 feet.

It will not be possible to discriminate sharply the upper and lower limits of the Schoharie waters, as the Herkimer waters fell slowly to the Schoharie and the latter to the next stage. If either of the changes had occurred suddenly and through a large vertical interval the two stages would be distinct in their deposits. However, within the extreme vertical limits as given above there is a large range of levels which must certainly correlate with the Schoharie stage.

The evidences of standing water will not be emphatic on the south side of the Mohawk valley as the steep, short slope, the shale rocks, and the weak streams are unfavorable to production and to preservation of delta deposits.

FOURTH STAGE: AMSTERDAM LAKE

The outlet channels of this stage are shown in plate 6, and the hypothetical position of the ice front in plate 15.

During the preceding stage, the Schoharie, the ice must have thrust itself against the high ground west of Schenectady, the Rotterdam salient, so as to block the direct outflow of the Mohawk valley waters by the present Mohawk, and forced the waters around through the Schoharie valley and out by the Knox and Delanson passes. In this third stage the ice front weakened on the Rotterdam salient so as to allow outflow by Rotterdam Junction and South Schenectady.

Theoretically the stream work of this stage must begin at a level below that of the Delanson channel, or 840 feet. At Pattersonville this plane might be 860 feet. Examination of the locality finds the facts in accord with the philosophy. The face of the hill three miles north of South Schenectady, forming the point of the great triangle between the Mohawk and Normanskill valleys, is strongly terraced and gullied down to 360 feet. The hollow on the northwest side of the hill contains a handsome channel at 580–600 feet. The face of the next hill shows stream work up to about 700 feet. The col between the heads of the Plotter kill and the Poentic kill is occupied by uncut moraine drift.

The general history of the ice recession in this district seems clear. The ice margin curved around the Rotterdam salient, with a

lesser tongue pushing up the Mohawk gorge and a larger lobation in the low ground to the southwest. The ice seems to have pressed against the slope west of South Schenectady while it weakened northward and opened the 600 feet gap between the two hills near the Mohawk, in such manner that the col at the head of the Plotter and Poentic kills was not subjected to stream cutting.

The detritus carried by the higher flow across the Rotterdam salient must have been swept on in confined waters, around the ice lobation, through Altamont and southward to quiet waters in the Hudson valley. The detritus of the later flow seems to have contributed to the sand plains about South Schenectady, with altitude of 340 feet.

The south wall of the Mohawk at Rotterdam Junction may have been undercut and steepened by glacial flow crowded against the slope.

Area and sand plains. Plate 15 shows the hypothetic extent of the lake as mapped for its middle phase. On account of its lower altitude the Amsterdam waters formed only a relatively narrow body in the Mohawk and Schoharie valleys, especially for the later phase. In the Rome district the waters spread more widely along the receding Ontarian ice; north of Fonda and Amsterdam they reached so as to flood the Sacandaga and upper Hudson valleys, as long as the lake stood over about 760 feet, below which the Sacandaga held a tributary lake (see page 35).

Allowing for deformation the higher plane of the waters in the district of the Lansing kill and upper Mohawk should be 70 feet over the Schenectady outlet, or up to about 900 feet. On the parallel of Rome the uplift is 60 feet and the latest plane would be about 420 feet.

The delta plains built in the Amsterdam waters by tributary drainage occur widely distributed over the basin and agree with the theoretic levels. The most massive deposits are naturally found at the debouchment of the heavy streams. On West Canada creek, south of Trenton village, the sand plains are from 880 down to 740 feet, being partly contributed by drainage from the Lansing kill lake. On East Canada creek, south of Dolgeville, the plains are from 800 feet down. At Johnstown are water levels at about 700 feet. In the Sacandaga valley are excellent terraces and extensive plains, shown in plate 8. North of the village of Northville is a fine plain at 860 feet. The plains of Northville and of Sacandaga Park are 800 feet. The higher levels of the broad plains south of Northville extending five miles to the Great Vly, declining from 800

to 720, belong to the Amsterdam lake; below about 780 they belong to the Sacandaga tributary lake. All the above figures are from the map contours.

In the narrow Mohawk valley the lowest levels are the most prominent, being the accumulations of detritus by downwashing into the bottom of the valley and leveling by the later waters. These plains include all the level stretches which are so conspicuous from the railroads in the valley. Following are some of the occurrences: at Oriskany, both sides of the valley, at 520–540; Frankfort, 500; Ilion, 500; Herkimer, 520; Fonda, 420–460; Tribes Hill, 420–440; Amsterdam, 420–440; near the mouth of Schoharie creek from 420 down. The most extensive plains lie north of Rome (plate 2), built by the heavy ice-border drainage along the north side of the ice lobe, at 600 down to 460 feet.

The occurrence of the lake plains in the Sacandaga valley and the lower Mohawk have been noted by Professor Brigham, and correctly attributed to a Mohawk lake, but without determination of the outlet channel (see title 6, pages 26–28).

FIFTH STAGE: LAKE ALBANY

The name Lake Albany has been given by Professor Woodworth to the body of water held in the Hudson valley in the Albany region in which were deposited the widespread sands and clays, partly shown in plate 6. This lake and its relations are described in State Museum Bulletin 84 (see title 40), and it is not the province of the present writing seriously to discuss the Hudson-Champlain lake history. Woodworth regards the Albany waters as lying against the receding ice front northward over the Fort Edward district as far as Fort Ann, and as extending south in a narrowing strip of water probably to Kingston. He supposed that the barrier on the south was due to elevation of the lower Hudson a few hundred feet above its present level, with probably some obstruction by morainal drift in the gorge of the highlands. The final draining of the lake he suggests might have been due to the removal of the drift barrier by the greatly increased volume of water when all the overflow of the Great Lakes was turned through the Mohawk valley, in Iroquois time.

The broad plains at South Schenectady, which we may consider the head of the Albany delta plains, are 340 feet elevation. Somewhat interrupted by glacial drift the lake plane steadily declines until at South Bethlehem, near the bottom of plate 6, it is 200 feet; and at Coeymans the deposits terminate at 160 feet.

Mohawk rivers. A very long time intervened between the extinction of Lake Amsterdam, establishing free drainage through the Mohawk valley, and the beginning of the present river. That interval was the glacial flow that endured until the Laurentian ice body weakened north of the Adirondacks sufficiently to open an escape for Lake Iroquois on the international boundary,[1] across Covey hill, lower than the Rome outlet.

Two periods of the glacial flow have been discriminated by the writer; one called the Glaciomohawk, which covered the flow previous to the establishing of Lake Iroquois, and the Iromohawk, the outflow of the Iroquois waters (see title 17, p. 38). The Glaciomohawk river endured while the central New York waters passed through four stages: the later Lake Vanuxem, the free drainage succeeding Vanuxem, the restored Vanuxem and Lake Warren (see State Mus. Bul. 127, plates 37–40). It is possible that the readvance of the ice front in the Syracuse district, during Second Vanuxem and Warren time, was accompanied by contemporary advance of the Hudsonian lobe so as again to block the Mohawk and produce a second Lake Amsterdam, but it is now only conjecture.

The Iromohawk endured from the time when the ice left the Rome district to the time when it had abandoned the Ontario basin and lay against Covey hill, on the north boundary of the State.

The volume of the Glaciomohawk was always much greater than that of the present river, and for part of its life it received all the drainage of central New York from as far west as LeRoy. The Iromohawk was a larger river than the St Lawrence. It not only carried the precipitation of the St Lawrence basin but received in addition the contribution from the melting of the accumulated ice body.

Remnants of the Iromohawk flood plains in the form of low terraces occur along the valley, especially near the junction of larger tributaries. They range in altitude from 440 feet at Utica to about 380 at Amsterdam and 360 at Schenectady.

The relation of Lake Albany to the glacial Mohawk is not clear. With the recession of the ice front from Schenectady we lose the key to correlation which we possessed during the earlier history, in the relation of ice-border channels to lake planes. The capacity of the intrenched channel of the river below Schenectady seems insuf-

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[1] Science, XXVI, 399; Sept. 27, 1907. Also (title 40) N. Y. State Mus. Bul. 84, p. 161–64, pl. 25.

ficient for a river comparable to the St Lawrence. It seems probable that Lake Albany endured to the close of Iroquois time.

River gradients and deformation. The present river from Rome (420 feet) to Schenectady (210 feet) falls 210 feet in 92 miles by the line of the valley (not counting the stream meanders), which gives 2.3 feet per mile. The actual slope of the river is much less above Herkimer. At and below Schenectady the river has intrenched itself about 130 feet below the head of its ancient delta, the Lake Albany plane. The Iromohawk river must have poured its flood across the delta, now 340 feet in elevation at South Schenectady. The col at Rome is now 430 feet. From this we must deduct about 55 feet for 27 miles of northing, making 375 feet the altitude of the head of the later Iromohawk channel. This gives a fall of 35 feet in 92 miles, or a gradient of 0.38 feet per mile. The elevation of the highest wave-built bars and spits in the Iroquois basin near Rome is 460 feet (see plate 2),[1] which gives 30 feet of water over the sill of the channel head, which is a normal depth for the great river. If we allow the same depth of water at the mouth of the river, and the South Schenectady deposits are fine, indicating submergence, we have the same moderate grade as for the channel bottom. These figures accord well with the grade of large rivers and indicate that our estimate of the deformation is fairly correct.

In the comparison of channels and lake plains in central New York and the Mohawk valley we find the northward uplift to be about 2 feet per mile, perhaps a trifle more. Hence if we allow this amount of uplift on the Rome meridian there is no balance left for east and west deformation. It is positive that through central New York, from Sodus to Rome, there is no appreciable east-west tilting since Iroquois time,[2] and it seems quite certain that the uniformity extends east to the Hudson; in other words, that the isobasal lines have here approximately east and west direction.

TRIBUTARY LAKES

Besides the Black valley waters which during most of their life were tributary to the Mohawk waters, as already described, other lakes were held at high levels along the margins of the ice lobes and found escape into the Mohawk. The lakes held in the valleys between Syracuse and Utica were described in the Twenty-second

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[1] The writer is indebted to Mr F. B. Taylor for first drawing attention to these features.

[2] See N. Y. State Bul. 127, p. 55.

Report of the State Geologist for 1902 (see title 17). Similar to these waters held along the south margin of the lobe were other local waters on the north side.

The high ground between the Ontario basin and the Black valley must have emerged from the ice sheet as an island in the broad water (plate 13). When this land mass became connected with the exposed land on the southeast (plate 14), or even earlier, the land drainage and the glacial outwash passed around the periphery of the open area until it reached the Mohawk escape. The greater portion of the high area is today drained westward by the numerous branches of North Sandy and South Sandy creeks, Salmon river and lesser streams, and southward by the west and east branches of Fish creek and the Mohawk river. All this heavy drainage was blocked by the ice during the time shown in plates 14–16. Each valley must have held its lake, and these poured from one into the other across the intervalley ridges until the augmented water reached the Mohawk valley. An example of such transverse channels is indicated in plate 4, in the vicinity of Lorraine east of Adams. The fragmentary channels here noted belong to a late stage of the ice recession in the district, but similar cross-ridge channels must of necessity occur higher on the slope and of earlier time. Plate 2 shows one strong channel of the earlier drainage lying between Fish creek and the upper Mohawk. No attempt is made to map the minor channels, to do which will require close examination of large territory.

Lansing kill lake. These few channels in plate 2, between Fish creek and the Mohawk, point us to the story of a distinct lake in the upper Mohawk district. When the ice margin had the position that is shown in plate 15 it formed an east-west dam lying on Quaker and South hills. All the west and south drainage of the highland east of Ontario basin flowed along the ice edge, producing larger ponding in the two valleys of Fish creeks, and outflowing at Point Rock into the Mohawk and then into the Lansing kill lake. This was subsequent to the opening of the Remsen channel, but while the St Lawrence glacier was pushing a lobe up (south) the Black valley. It will be remembered that earlier the Lansing kill waters had been a branch of the Forestport lake, the connecting strait being the head of the Lansing kill valley, north of Potato hill. The time here recorded is that of the Port Leyden stage in the Black valley and the late Schoharie and early Amsterdam stage in the Mohawk basin. A profusion of delta terraces are found in the upper Mohawk-Lansing kill basin which fall into three categories;

a few of the highest, ranging above 1200 feet, probably represent the Forestport level, while those from 1200 down to about 900 feet belong to the Schoharie lake, which seems to have entered the basin through the Steuben valley northwest of Trenton. Below 900 feet the terraces must correlate with the Amsterdam waters, or below 830 feet (the Steuben col) with the local lake.

The ice seems to have lingered on the southwest flanks of Quaker and South hills while the Schoharie lake fell to the Amsterdam lake, and then the Lansing kill river extended itself through the Steuben valley.

When the ice weakened on the flank of Quaker hill the ponded waters of Fish creek and tributaries found their outflow through the splendid series of strong channels west and east of Lee Center; and at the same time, the ice waning on the western slope of South hill, the waters found their ultimate escape by channels at Delta, Floyd and Marcy, at 600 to 500 feet, into Mohawk waters of late Amsterdam stage. These features are shown in plate 2.

As the Port Leyden lake (Copenhagen outlet, see page 13), following the suppression of the Boonville river, was probably as late as early Iroquois time, and as the initiation of Lake Iroquois was in the Rome-Oneida district, it follows that the Lansing kill and upper Mohawk valleys held glacial waters from at least the time of Forestport lake down to initiation of Iroquois. The ice here made its most determined stand, at the head of the Mohawk valley; and the consequent production of channels and deltas make it the critical locality for correlation with similar effects of the ice barrier at the east end of the Mohawk valley.

Of the many marginal lakes, mostly small, which the ice held on the north and the south slopes of the Mohawk valley only one will be described here, though a close study will discover many interesting details of the history.

Sacandaga lake. A large lake tributary to the Mohawk waters was held in the Sacandaga and upper Hudson valleys. From its sources in the southeastern Adirondacks this river enters a broad valley at Northville and at Northampton turns northeast and joins the Hudson at Luzerne. During all the time covered by this history the Hudson drainage was blocked by the Hudsonian ice lobe and the waters of all the Adirondacks were forced into tribute to the Mohawk lakes. During the life of the Schoharie lake the ice lay across the upper Hudson somewhere in the district of Corinth, covering the area of Saratoga and Ballston, and the Schoharie waters must have flooded the territory of Johnstown, Gloversville,

Northville and the canyon of the upper Hudson, so much as then existed. These waters at their lowest level must have been 840 plus 70 feet for tilting, making the water 900 feet at Northville and Corinth. The Sacandaga at Northville is now 740 feet, and the Hudson at Corinth is today only 520 feet.

When the Schoharie lake was succeeded by the Amsterdam lake the Hudson valley was still blockaded and the lake covered Northville; but when the Amsterdam water fell to about 750 feet, on the Gloversville parallel, the Sacandaga-Hudson waters became a distinct lake, with outlet southward by a pass four miles southeast of Gloversville, at 760 feet. For two miles below the col this outlet is a fair channel, but half way to Johnstown it becomes narrow, though in shale, and unsatisfactory as an outlet channel of a large lake. However, with the present conception of the events connected with the ice recession it seems positive that the Sacandaga-Hudson waters must have outflowed here into Lake Amsterdam. This tributary lake must have persisted until the recession of the ice in the Saratoga and Ballston district opened a lower escape for the Hudson waters at South Corinth. The Saratoga topographic sheet shows the pass at South Corinth, at 636 feet, leading southward to the Kayaderosseras creek. The valley of this stream shows excellently the work of a short-lived river of high gradient and large volume. Below Middlegrove and at Rock City Falls the valley walls are severely cut and heavy deposits of coarse cobble detritus lie far above the present stream. The very extensive sand plains at Ballston Spa and northward are the delta built by the glacial Hudson, debouching at above 400 feet altitude in the late Amsterdam or early Albany lake. This escape of the Hudson waters would seem to have existed as late as the close of Lake Amsterdam and the establishment of Lake Albany over the Schenectady district.

The name for this lake was given by Professor Brigham, who has briefly described the Northville deltas (see title 6, pages 26, 27). Plate 8 indicates in a general way the features of the Northville district.

THE ROCK BARRIER AT LITTLE FALLS

One questionable factor in the glacial history is the effect on the drainage and the time of the downcutting of the rock col at Little Falls.

In a former paper (see title 17, pages 22, 30–33) the writer attributed some features in the Mohawk valley above Little Falls to the ponding effect of the rock barrier, with perhaps some help

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BULLETIN 160 PLATE 8

74° 15′ 10′ 74° 5′
43° 15′

Scale 1/62500
0 1 2 3 Miles
Contour interval 20 feet.
Datum is mean sea level.

BENSON
HAMILTON CO.
FULTON CO.
Buell Mt.
Northville
Sacandaga Park
Edinburg
Butler
Valley
Glyndon
NORTHAMPTON
Bunker Hill
Osborn Bridge
Tamarack Swamp
GLOVERSVILLE
RIVER
SARATOGA CO.
FULTON CO.
SACANDAGA
B.M. 763
Cranberry Creek
Cranberry
Jacobson
Creek
Johnstown
Roberts
Creek
Vly
Creek
Creek
Northampton
(Fishhouse)
B.M. 789
Benedict
Frenchman
Beaver
Creek
North
Broadalbin
Creek
Munsonville
Mayfield
FONDA

GLACIAL WATERS
IN THE
MOHAWK AND SACANDAGA VALLEYS
H. L. FAIRCHILD
1909

LEGEND

DELTAS AND SANDPLAINS

- *Schoharie lake*
- *Sacandaga local lake*
- *Amsterdam lake*

INTERPRETATION

COMPARE MAPS, PLATES 14-15

Only a few of the lake plains are mapped. Other high delta plains must exist between Northville and Edinburg. The swamp areas are probably detrital fillings in the lakes.

43° 5′ 74° 15′ 10′ 74° 5′ 43° 5′

from morainal drift and lake deposits. Later study makes that conclusion seem improbable.

The lacustrine plains and terraces in the upper Mohawk and north of Rome are now found to correlate with the glacial lakes held in the whole extent of the Mohawk valley by the Hudsonian ice lobe. While the ice lay over Rome there was drainage past its northern edge at as low elevation as 500 feet; and as early in the glacial lake history of central New York as the close of Lake Vanuxem (see title 19, page 57 and plates 37, 38) there was free eastward flow through Syracuse as low as 400 feet, present altitude. The low altitude of the Syracuse passes as compared with the Rome col, 430 feet, seems partly due to the northerly position of Rome, some 12 miles, which gives at least 25 feet of relative uplift for the Rome parallel.

In plates 15 and 16 of this paper we make the low Syracuse drainage correlate with Lakes Amsterdam and Albany. It could not have been earlier than this stage, unless in some deglaciation interval as yet unrecognized. It does not seem probable that it was later, because lying in time between this and Iroquois time in central New York is the readvance of the ice at Syracuse and the considerable period of Lake Warren and the Hyper-Iroquois waters. We must not assume too great difference between the waning of the ice fronts in the Syracuse and the Albany districts.

It does not seem possible that any considerable lowering of the hard rock barrier at Little Falls could have been accomplished by the moderate flow during merely the closing phase of the Amsterdam lake. But this seems imperative if we attribute all the cutting to that one episode of lowering waters; for when the outflow on the Rotterdam salient was under 600 feet the Little Falls pass was under Amsterdam lake water, and at what now appears to have been the end of the Amsterdam stage the pass was as low as it is now.

It is believed that the glacial phenomena in New York are not the work of a single ice invasion but the product of two or more invasions. This being conceded it follows almost certainly that the production of glacial lakes must have been repeated, and the probable outflow have been similar to the latest. In this view the large drainage channels were not wholly cut by the latest rivers. In accordance with the above it seems altogether probable that the rock barrier at Little Falls was chiefly or entirely cut by Prewisconsin drainage, and that the Glaciomohawk and Iromohawk[1] rivers had

[1] These names for the glacial river were given in 1904. See title 17, p. 38.

only to remove some filling of drift and do a small amount of rock cutting to produce the present pass. The rock shelves were probably cleared of drift and exposed as we now find them (title 17, plates 13–25) by wave action of Lake Amsterdam waters.

This fact is certain, that the Little Falls pass was cut to nearly its present depth while the ice lay over Rome, and far antedating the time when the flood from the Great Lakes poured through the valley. We are compelled to the conclusion either that the trenching was Prewisconsin or that the Mohawk drainage history connected with the Wisconsin ice retreat is much more complicated than we can now appreciate.

THE DIVIDE AT ROME

Closely connected with the problem of the rock pass at Little Falls is that of the divide at Rome. It is a singular fact that the col or divide at Rome, the place of outflow of Lake Iroquois, on which headed for many thousand years a river as large as the St Lawrence, is not rock but detritus, gravel, sand and clay. This lake and stream deposit has a large area (see plate 2) and extends down the Mohawk valley about 30 miles. Well borings at Rome (see title 5, page 190) show that the depth of these water-laid deposits is considerable, in places over 100 feet. Brigham gives the rock bottom at Rome as 320 feet, and at Little Falls 376 feet. It appears that if the valley were cleared out to the rock the Mohawk river would head at Little Falls and that a lake would occupy the ground west of that point.

It has long been recognized that in Preglacial time the drainage divide was at Little Falls (see title 8, page 362) and that the water west of Little Falls was tributary to a trunk stream in the Ontario valley. It seems probable that in the earliest flow of the Glacio-mohawk the stream headed at Little Falls while the valley westward was occupied with quiet or lake waters, though it may have been filled by glacial drift. However, any waters of the narrow lake would have been soon displaced by the abundant detritus swept in by the ice drainage and West Canada river and the conditions changed from lacustrine to fluviatile. As the ice lobe melted back, westward, the detrital filling probably followed it.

The deep alluvial deposit at Rome, which now creates the divide between St Lawrence and Mohawk drainage, is the delta built by the heavy glacial drainage from the north and northwest during Lake Amsterdam time (see plates 2, 15, 16). During all the life of Lake Iroquois the detrital contribution of the upper Mohawk seems to have been sufficient to block the outflow and to establish the

wasteweir or stream head at Rome. A little cutting would today divert the flow of the Mohawk westward into Wood creek.

SUMMARY OF THE MOHAWK DRAINAGE HISTORY

Stage 1. The axis of the valley was occupied by a strait of ice connecting the two ice bodies in the Hudson and Ontario valleys. The waters of the Adirondacks escaped across the ice, the overflow probably being into the Otsego-Susquehanna valley. Sand plains through the Adirondacks with elevation 1450 and upward probably correlate with this stage. See plate 12.

Stage 2. The melting of the strait of ice in the valley left a stretch of open water between the ice tongues, the Herkimer lake. The water had two successive outlets, by Summit lake pass to the Otsego-Susquehanna at 1360 feet, and by the Cedarville pass to the Unadilla-Susquehanna, at 1220 feet. Correlating sand plains of great expanse occur in the basins of the upper Mohawk, West Canada and East Canada creeks at 1440 to 1280 feet. See plates 2, 5, 7, 13. The Black valley basin was flooded by the waters of this stage, so far as relieved from the ice sheet.

Stage 3. Waning of the Hudsonian ice lobe permitted escape of the waters along the face of the Helderberg scarp, west of Albany, the later flow being across the divide between the Schoharie and Hudson valleys, at Delanson, 840 feet. Correlating sand plains exist in many localities with elevation, according to latitude, from 1200 down to 820 feet. See plates 2, 7, 8, 14. The Black valley waters were now tributary to the Schoharie lake, first through the Remsen outlets and later by the Boonville outlet, as shown in plate 2.

Stage 4. Amsterdam lake. Further recession of the Hudson valley ice lobe permitted outflow of the waters about the Rotterdam salient, west of Schenectady, at 800 down to 360 feet. See plate 6. The correlating delta plains are widely distributed, having altitude in the Rome district of 860 to 460 feet. See plates 2, 8, 15. The Black valley waters were still tributary and two other tributary lakes were the Lansing kill and the Sacandaga. See plate 8.

Stage 5. Lake Albany, confined to the Hudson valley, with outlet control southward. The Mohawk valley now had free drainage, two phases being the Glaciomohawk, previous to Iroquois time, and the Iromohawk, the overflow of Lake Iroquois.

CORRELATION OF THE ONTARIAN AND HUDSONIAN ICE LOBES

Maps of the waning ice sheet. Plates 9–17

The criteria or data for determination of the positions of the ice fronts and the construction of the maps are found in the following facts:

1 Deltas or sand plains indicate approximate heights of lake surfaces and prove that open water existed at the locality when the deposits were laid, the ice being removed.

2 Stream channels indicate approximate heights of the outflowing lake, with some allowances for depth of the rivers, and imply lower levels for the receiving waters. Streams across cols must be lake outlets.

3 A series of stream-cut channels on a land slope imply a lowering barrier, the receding ice front holding the streams to their work.

4 A channel in the bottom of a col or valley with no stream work on the wall of the valley indicates that standing or open water was lowered on the valley until flow was established across the divide.

5 The border of the glacier must have had general uniformity of height, resting like a lake or river against the land, but with some rise toward the source of supply and declining downstream.

6 In comparison of features relating to lake planes some deformation of the land must be recognized.

Contemporaneous positions of the two ice fronts, far separated in the Ontario and Hudson valleys, have been quite definitely determined in a few localities by means of criteria noted above. In the Ontario basin near the head of the Mohawk valley we find an abundance of glacio-lacustrine phenomena which must have altitude relation to the eastward escape of the same lake waters; and it is found that such eastward outflow was controlled by the glacier in the Hudson valley. When the outlet channels are along a steep slope, like those on the face of the Helderberg scarp or on the hills west of Schenectady, we may be sure of the precise position of the ice front there at the time when the imprisoned lake had corresponding altitude. At the Ontario end of the lake the positions of the ice front can be determined approximately by means of inflow channels and deltas, in their relation to the lake surface. For example, the deltas at Trenton and Trenton Falls indicate subsiding lake waters,

and the correlating outlets can be nowhere except through the Delanson hollow and on the face of the Helderberg scarp, where the ice-compelled rivers have left their unmistakable tracks. At Lee Center, northwest of Rome, and eastward are sluggish-flow channels at declining levels, made along the stagnant ice margin, while the lake levels were controlled by the ice front on the Rotterdam salient.

From localities of known position for the ice margin the latter can be extended theoretically, lapping on the land at levels slowly rising northward and falling southward.

Between known positions of the ice at different periods the location for time intermediate can be approximately interpolated.

The maps (plates 9–17) are an attempt to portray several stages in the recession of the latest ice sheet. A continuous waning of the glacial lobes is suggested by the maps. However, the ice sheet did not pass away by continuous and steady recession but by oscillations, readvances and reretreats; and some of the readvances may have covered considerable territory and have seriously changed the drainage. At present our knowledge of these elusive changes in the glaciers in the Mohawk-Hudson region is almost nothing and no account can be taken of them.

The maps make no claim to accuracy, except at a few points for a few stages in the history. They are only suggestive and intended to give in a graphic way the broad facts in the general history. The positions of the ice limits as indicated in the maps are separated by long periods of time, perhaps in some cases thousands of years, during which oscillations of large extent may have occurred. The positions of the ice fronts at both ends of the Mohawk valley are definite for the phases shown in plates 14–16.

These maps are an extension and correction of plates 34–42 of the preceding paper (N. Y. State Museum Bulletin 127) on Central New York drainage.

Between the stages depicted in plates 16 and 17 is a very long interval unmapped. During this time central New York had a varied lake history, including at least the Second Vanuxem, Warren and Hyper-Iroquois waters. If the ice in the Hudson advanced in sympathy with that in the Syracuse district it may have again blocked the Mohawk valley. But with the beginning of Lake Albany we have no means, now recognized, of comparing the limits of the ice in the Hudson valley with those in the Ontario. Rather than depict stages between those of plates 16 and 17 in a purely

hypothetical way, they are omitted. In plate 17 the limits of the Champlainic ice lobe is a matter of conjecture.

It is only hoped that these maps will serve as suggestion and stimulus to more detailed study of the glacial phenomena, and that the future student may be able to translate much more of the wonderful history.

BIBLIOGRAPHY

The literature on the Pleistocene of the Black and Mohawk valleys is scanty, the only comprehensive paper being one by Professor Brigham (title 4). Most of the geologic work in the areas of the Black, Mohawk and Schoharie valleys has been concerned with the stratigraphy and paleontology.

The following list includes writings which have some reference to the physiography, surficial geology and Pleistocene history of the region. Papers that discuss only the stratigraphy or paleontology of the region are not included.

A list of papers relating to the region adjacent on the west may be found in the latest paper by the writer (title 19) and an extended list bearing on the Pleistocene of New York and the Champlain-Hudson district in particular is contained in Professor Woodworth's paper on the Champlain and Hudson valleys (title 40).

For convenience of reference in the preceding text, the titles are given numerical order, the arrangment being alphabetic by authors.

1 **Baldwin, S. P.** Pleistocene History of the Champlain Valley. Amer. Geol. 1894. 13:170–84.

2 **Brigham, A. P.** The Geology of Oneida County, N. Y. Oneida Hist. Soc. Trans. 1887–89. p. 102–18.

3 ——— Drift Boulders between the Mohawk and Susquehanna Rivers. Amer. Jour. Sci. Ser. 3. 1895. 49:213–28.

4 ——— Glacial Flood Deposits in Chenango Valley (N. Y.). Bul. Geol. Soc. of Amer. 1897. 8:17–30.

5 ——— Topography and Glacial Deposits of Mohawk Valley. Bul. Geol. Soc. of Amer. 1898. 9:183–210.

6 ——— Report of Field Work and Summary of Results (no title). Fourth An. Rep't Director of Science, N. Y. State Mus. Bul. 121, 1908. p. 21–31.

7 **Chadwick, G. H.** Glacial Lakes of the Catskill Valley. Science 1910. 32:27, 28.

8 **Chamberlin, T. C.** Terminal Moraine of the Second Glacial Epoch. U. S. G. S. Third An. Rep't 1883. p. 351–60.

9 **Cushing, H. P.** Geology of the Vicinity of Little Falls, Herkimer County. N. Y. State Mus. Bul. 77. 1905.

10 **Dana, J. D.** On the Existence of a Mohawk Valley Glacier, etc. Amer. Jour. Sci. 1863. 35:243–49.

11 **Darton, N. H.** A Preliminary Description of the Faulted Region of Herkimer, etc. Fourteenth An. Rep't N. Y. State Geologist. 1897. p. 33–53.

12 **Dwight, Timothy.** Travels in New England and New York. New Haven. 1822. p. 33–128.

13 **Eaton, Amos.** Geological and Agricultural Survey of the District Adjoining the Erie Canal. Albany. 1824.

14 **Eights, J.** Post-Tertiary of the Vicinity of Albany. Albany Inst. Trans. 1852. 2:335–53.

15 **Emmons, Ebenezer.** Geol. N. Y., Second District. Albany. 1842. p. 335–417.
16 **Fairchild, H. L.** Latest and Lowest Pre-Iroquois Channels Between Syracuse and Rome. N. Y. State Geologist. Twenty-first An. Rep't 1903. p. 32–47.
17 ——— Glacial Waters from Oneida to Little Falls. N. Y. State Geologist. Twenty-second An. Rep't 1904. p. 17–41.
18 ——— Geology of the Black River Valley. Carthage Tribune. Carthage, N. Y. Aug. 17, 1907.
19 ———Glacial Waters in Central New York. N. Y. State Mus. Bul. 127. 1909.
20 ——— Glacial Waters West and South of the Adirondacks. Science. April 16, 1909. 29:627.
21 ——— Correlation of the Hudsonian and the Ontarian Glacier Lobes. Science. April 16, 1909. 29:627.
22 **Gilbert, G. K.** Comments on paper by J. W. Spencer (no. 33). Geol. Soc. Amer. Bul. 1892. 3:492–93.
23 **Grabau, A. W.** Guide to the Geology and Paleontology of the Schoharie Valley, etc. N. Y. State Mus. Bul. 92. 1906. p. 333–52.
24 **Harris, T. W.** The Kames of the Oriskany Valley. Amer. Geol. 1894. 13:384–90.
25 **Hough, F. B.** Observations on the Geology of Lewis County. N. Y. Amer. Quar. Jour. Agr. and Sci. 1847. 5:324–26.
26 **Mather, W. W.** Geol. N. Y., First District. Albany. 1843.
27 **Miller, W. J.** Geology of the Remsen Quadrangle. N. Y. State Mus. Bul. 126. 1909.
28 ——— Pleistocene Geology of the Southwestern Slope of the Adirondacks. Science. April 16, 1909. 29:627.
29 **Ogilvie, I. H.** On Glacial Phenomena in the Adirondacks, etc. Jour. Geol. 1901. 10:397–412.
30 **Peet, C. E.** Glacial and Postglacial History of the Hudson and Champlain Valleys. Jour. Geol. 1904. 12:415–69; 617–60.
31 **Rich, J. L.** Local Glaciation in the Catskill Mountains. Jour. Geol. 1906. 14:113–21.
32 **Smock, J. C.** Evidences of Local Glaciers in the Catskill Mountain Region (abstract). Amer. Assoc. Adv. Sci. Proc. 1885. 33:403–4.
33 **Spencer, J. W.** Channels Over Divides Not Evidence per se of Glacial Lake. Geol. Soc. Amer. Bul. 1892. 3:491–92.
34 **Tarr, R. S.** Physical Geography of New York State. New York. 1902.
35 **Taylor, F. B.** Deltas of the Mohawk. Amer. Geol. 1892. 9:344–45.
36 ——— Lake Adirondack. Amer. Geol. 1897. 19:392–96.
37 **Upham, Warren.** Late Glacial or Champlain Subsidence and Re-elevation of the St Lawrence River Basin. Am. Jour. Sci. Ser. 3. 1895. 49:1–18; Geol. & Nat. Hist. Surv. of Minn. Twenty-third An. Rep't 1895. p. 173–81.
38 ——— Deltas of the Hudson and Mohawk Valleys. Amer. Geol. 1897. 9:410–11.
39 **Vanuxem, L.** Geol. N. Y., Third District. Albany. 1842.
40 **Woodworth, J. B.** Ancient Water Levels of the Champlain and Hudson Valleys. N. Y. State Mus. Bul. 84. 1905.

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New York State Museum

JOHN M. CLARKE, Director

Museum Bulletin 162

THE LOWER SILURIC SHALES

OF THE

MOHAWK VALLEY

BY

RUDOLF RUEDEMANN

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New York State Education Department

Science Division, May 14, 1912

Hon. Andrew S. Draper LL.D.

Commissioner of Education

SIR: I have the honor to communicate to you herewith a manuscript entitled *The Lower Siluric Shales of the Mohawk Valley,* with accompanying plates. This work has been prepared by Dr Rudolf Ruedemann, Assistant State Paleontologist, and is the result of careful and protracted observations. I recommend it, subject to your approval, for publication as a bulletin of the State Museum.

Very respectfully

JOHN M. CLARKE

Director

STATE OF NEW YORK

EDUCATION DEPARTMENT

COMMISSIONER'S ROOM

Approved for publication this 15th day of May 1912

A. S. Draper

Commissioner of Education

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THE LOWER SILURIC SHALES OF THE MOHAWK VALLEY

BY RUDOLPH RUEDEMANN

INTRODUCTION

While engaged in mapping the shales of the Saratoga and Schuylerville quadrangles of the State of New York, the writer has found that in order properly to correlate the formations of fossiliferous shales appearing there with the standard formations of the State, it would be necessary to trace their relation to the Utica and Frankfort shales through the Mohawk valley. In beginning this task in Schenectady county, an unexpectedly large and interesting fauna was found in the "Frankfort shale" of that county hitherto considered as practically barren. This discovery promised a safe conclusion as to the as yet unknown faunal and taxonomic relations of the Frankfort shale to the Utica shale on the one hand, and to the Lorraine beds on the other. The close faunistic and stratigraphic relations of the Frankfort shale to the Utica shale were early recognized in the work, and as the writer had previously (title 60[1], page 44) obtained evidence of the different faunal aspect of the "Utica shale" of the lower Mohawk from the typical shale at Utica, it was found desirable to include the Utica shale in the investigations.

[1] See Bibliography, p. 69.

It was further found that beds formerly considered by the author (op. cit., page 29) as representing one formation (the Magog), had to be divided into two units, the Canajoharie shale and the Snake Hill beds. These beds are not only in juxtaposition about the mouth of the Mohawk, but even intermingled in that much-folded territory, and we originally considered them as both belonging to the Mohawk series and therefore have described also the Snake Hill beds in this paper. Later work has, however, shown that the Snake Hill beds were deposited in the Levis basin upon the Normanskill shale and have been brought to the mouth of the Mohawk and in contact with the Canajoharie beds by the overthrusting and compression of the shales of the Levis basin. We have nevertheless added the description of the Snake Hill fauna in the present paper, first, on account of its present occurrence in the lowest Mohawk valley, then, because of the intermixture of Snake Hill beds with Canajoharie shale, and, finally, because of the faunal similarities suggesting their equivalence. The Snake Hill formation finds, however, its principal development in the area of the Schuylerville sheet, and will therefore be more fully described in the report on that region, soon to be published.

Evidence was soon obtained that the lower part of the Utica shale of the lower Mohawk valley is older than the typical Utica shale and probably of Trenton age, and it would have been desirable to also trace the Trenton limestone from its type section at Trenton Falls to its much smaller section in the lower Mohawk valley. Time was lacking for this undertaking but fortunately Doctor Ulrich has furnished us important data as to the Trenton limestone, and we are glad to acknowledge here our obligation to him not only for this information, but also for advice in the identification of fossils, and many valuable suggestions as to the broader bearings of the problem.

We are also under obligation to Mr David White for the valuable notes on the interesting seaweeds collected in the Schenectady shale (see page 73), to Prof. Bashford Dean, Dr L. P. Gratacap, Dr H. A. Pilsbry for advising us in regard to the problematic fossils from the Schenectady shale, here described (see page 74), to Prof. A. F. Foerste for information regarding certain brachiopods and to Dr E. O. Hovey for the loan of type specimens from the American Museum of Natural History.

HISTORICAL SKETCH

A perusal of the literature shows that the Utica and Frankfort shales have received scanty attention from geologists, quite obviously because they promise little, if any, results, the Utica shale fauna consisting largely of small species difficult of study. The Frankfort shale was declared by Vanuxem to be remarkably deficient in all organic remains excepting graptolites. A fairly full account of the two was given by Vanuxem in the *Geology of the Third District*. This astute observer distinguished the Utica slate and the Frankfort slate; the latter as a subdivision of the Hudson River group or Lorraine (Emmons), the other member being the Pulaski shale. He states that in his district (which included the Mohawk valley) the Utica slate is everywhere underlain by the Trenton limestone and overlain by the Frankfort shale and sandstone; that both the Utica and Frankfort beds enter his district from the first district on the lower Mohawk and are coextensive there, while the Pulaski shale first appears much farther west in Oneida county. The Utica slate is characterized as deep bluish black rock, generally fissile, exhibiting a brownish or dark chocolate color by weathering and associated with thin layers or flags of dark colored impure limestone, especially in the lower part of the mass. As characteristic fossils, that do not come up from the Trenton, are cited:

Triarthrus becki, Graptolites dentatus (either Dipl. foliaceus or Glossogr. quadrimucronatus), a mutation of Trocholites ammonius and Graptolites scalaris (Diplograptus and Climacograptus viewed from in front).

The Frankfort slate is stated by Vanuxem to change by imperceptible gradation from the Utica slate, "yet a separation would seem obvious from the fact that the dark blue or black color of the latter disappears in the usually light color of the former. While the Utica slate alternates at its lower part with thin beds of dark colored impure limestone, the Frankfort slate, on the contrary, alternates with a peculiar sandstone to which Professor Eaton gave the name of rubblestone; and while the Utica slate is calcareous, the Frankfort slate is wholly destitute of calcareous particles." He continues: "Both slate and rubblestone" (greywacke of Eaton, an impure argillaceous sandstone), "lose their bluish color when long exposed, and assume a dull dark gray, green or olive color, which is very characteristic of this rock, and by which it is readily

distinguished from the Utica slate, which as before mentioned, changes to a brown." Vanuxem comments on the thinning of the Frankfort beds westward and it is obvious from his remarks (page 61) that he also considered the greater part of the shales in the Hudson valley as of Frankfort age, largely on account of the intercalation of similar rubblestone or greywacke. He describes the Frankfort shale as remarkably deficient in organic remains, stating: "From the eastern end of the Helderberg to Oneida county, I have seen but one fossil shell in the whole mass." Only graptolites are said to be numerous in a few places; this statement, however, refers principally to the shale in the Hudson valley, which we no longer refer to the Frankfort beds. He also found a small specimen of Triarthrus becki and two of Trinucleus concentricus ("Cryptolithus").

In the middle Mohawk valley the Frankfort slate is capped by the Oneida conglomerate, but in the upper valley and to the west of the Adirondack region it is overlain by the Pulaski shale, or rather it is separated from the typical Pulaski shale by an "intermediate area" (Vanuxem, page 64) with a separate fauna which Vanuxem considered a lower subdivision of the Pulaski shales.

Hall, in volume 1, Palaeontology of New York, brought out the fundamental paleontologic data for the formation in question. He distinguished the faunas of the Utica slate and of the Hudson River group, the latter comprising all the horizons of the shales in the Hudson valley, including the Frankfort and Pulaski (Lorraine) beds.

In volume 3, Palaeontology of New York, Hall extended the term Hudson River group to "all the beds from the Trenton limestone to the Shawangunk conglomerate," a conception which was taken up by the textbooks and came into general use.

In an attempt to correlate the Normanskill shale with the Utica formation, Whitfield (title 7) cited several Normanskill graptolites (Didymograptus serratulus, Dicranograptus ramosus, Climacograptus bicornis) from the Utica shale of the neighborhood of Fort Plain in the Mohawk valley as proof of his contention. The writer has shown (1901, 1908) that this view is based on the wrong identification of these graptolites. It had, however, an important influence in inducing later authors to refer a large part of the shales of the Hudson valley to the Utica shale.

Walcott (title 9) in his "Utica Slate and Related Formations," distinguished the Utica epoch from the Trenton and Hudson River epochs and added a considerable number of new types (two species of the sponge genus Cyathophycus, species of graptolites of the genus Dendrograptus, Leptograptus annectans and a few other forms) to the list of hitherto known Utica species. In his "Catalogue of Fossils Occurring in the Utica Slate" (page 34), he brought the Normanskill shale with its graptolites into the Utica shale as an upper division. The geographic distribution of the Utica shale within and outside of New York was fully discussed by him. The presence of passage beds between the Trenton limestone and Utica slate in the region of the type section is also commented upon (page 10). The thickness of the Utica shale, before greatly underestimated, is given as over 600 feet at the type section.

Beecher published in 1883 (title 13) a list of fossils from the black shales near the old Dudley Observatory, at Albany, referring the beds to the Utica epoch and Ford, a year later, recorded the discovery of a few fossils (Graptolithus pristis, Gr. mucronatus, Triarthrus becki and Lingula curta) in the slaty and arenaceous rocks in the vicinity of Schenectady, which on the strength of this evidence he also considers as of Utica age, while the preceding authors (Vanuxem) had referred it to the Frankfort slate, respectively Hudson River shale (Mather, Emmons).

In 1890, Walcott in a paper on "The Value of the Term Hudson River Group," asserted the continuation of both the Utica slate and Frankfort shale into the Hudson valley, thereupon basing his argument for the extension of the term "Hudson River group" to all beds between the Trenton limestone and Upper Siluric. As before, he included the Normanskill shale in the upper Utica epoch or lower Frankfort. The fauna discovered by Beecher at the Dudley Observatory was correlated with the upper Utica and that from the glazed slates at Cohoes (whence Hall in Palaeontology of New York, volume 1, reports Ambonychia radiata, etc.) to the Frankfort shale. The important fact is pointed out that a well drilled at Altamont (Knowersville), 17 miles west of Albany, gave a thickness of 3475 feet for the strata between the Lower Helderberg limestone and the Trenton limestone. On account of its proximity this section allows a good estimate of the great thickness of the Utica and Frankfort shales in the lower

Mohawk region, which is only about 10 miles to the north over a continuous outcrop of Frankfort beds.[1]

Darton did not make any special study of the Utica and Frankfort beds for his "Geology of the Mohawk Valley" (1893).

Of great importance for the present work were the investigations of Prosser and Cumings (titles 33, 44). They described a number of sections through the Utica slate and the Frankfort beds (their Hudson River group) and demonstrated the great thickness of these groups in the Amsterdam quadrangle (Utica 950–1260, Frankfort 1200 +)[2]. Among other things, they made known in the Minaville section a complete transition from the Utica to the Frankfort beds. From the base of the Minaville section a fairly complete section can be obtained along Chuctenunda creek through the Utica down to the Trenton limestone and thus it has been possible for us to study a continuous section from the Trenton to the Frankfort in the lower Mohawk valley. A list of eighteen species is given for the Utica slate at Canajoharie, and a small faunule recorded from the Hudson River shale near the Schenectady pump station, namely, Triarthrus becki, Trinucleus concentricus, Plectambonites, sericeus, Orthis (Dalmanella) testudinaria, Orbiculoidea sp., Monticulipora (Prasopora) lycoperdon, crinoid segments and graptolites.

A few notes on the Frankfort shale sections along Moyer creek near Frankfort (the type section) and Ferguson creek near Utica were published by Theodore G. White in 1899 and the presence of Triarthrus becki, a small Orthis, a small Orthoceras and graptolites recorded in these sections.

Purely paleontologic papers on fossils from the Utica slate of the Mohawk valley were published in the decade of 1890–1900 by Beecher on Triarthrus becki and by Ruedemann on the development of graptolites, and a sessile Conularia. Ruedemann (title 36) also demonstrated that in the Utica shales of the Mohawk valley distinct evidence is found of marine currents following a northeast-southwesterly course.

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[1] The terms Trenton limestone, Utica and Frankfort shales are used in this introduction in their old meaning, not in the restricted conception given to them in this paper.

[2] Cumings (1900, page 462) measured an actual thickness of the Utica slate of 1160 feet in the Adebahr hill section.

In 1901, the author (title 47) in his bulletin on the Hudson River beds near Albany, correlated the Normanskill shale with the lower Trenton and argued on this account for the suppression of the term Hudson River group. He also pointed there (page 560) to the decrease of the thickness of the Trenton limestone eastward in the Mohawk valley and the rapid increase of the "Utica" shale in the same direction. In the following years the author also showed the presence of graptolite zones ranging from the top of the Cambric through the Beekmantown and Trenton to the Utica in the Hudson River shales. A broad belt of shales on the west side of the Hudson overlying the middle Trenton shales and Normanskill shales was still referred to the Utica shale; and the shales at Cohoes and to the west of the Utica belt were in accordance with Hall and Vanuxem correlated with the Frankfort division of the Lorraine group, mainly on the ground of a series of small lamellibranchs obtained about Cohoes and of the supposed upper Utica aspect of the Dudley Observatory faunule.

In 1902 Paleozoic Seas and Barriers in Eastern North America by E. O. Ulrich and Charles Schuchert was published. This very important paper, which apparently has not been sufficiently understood or appreciated by many, has helped greatly in the elaboration of the complex shale problems by pointing to the existence of separate troughs or channels in the shale region (the Chazy and Levis troughs) of New York and to the draining of these channels independently of each other.

Clarke in the Classification of the New York Series of Geologic Formations (title 52) discarded the term Hudson River and distinguished the Utica shale and Lorraine beds as stages of the Cincinnatian; the Frankfort shale, Pulaski and Salmon River being considered as "early terms applied to the local development of these beds in central New York."

In an excellent description of the Geology of Little Falls, Cushing (1905) pointed out the presence of 100 feet of passage beds between the Trenton and Utica. He says: "Lithologically these beds are no more Trenton than they are Utica but are distinctly intermediate in character, and no more to be classed with the one formation than with the other." He mapped them as a distinct unit, and in a later communication to Professor Miller (title 65, page 21) he proposed the term *Dolgeville shale* for these passage beds, considering them a formation "as a shaly eastern representative of the upper Trenton limestone of the type section."

These beds were found by Miller (title 65) to be absent on the Remsen quadrangle which adjoins the Little Falls quadrangle to the west.

The graptolites of the Utica shales and supposed Frankfort beds of the Hudson valley have been fully described by the author in volume 2 of Graptolites of New York (1908). The Utica shale is there characterized as the zone of Glossogr. quadrimucronatus and Climacograptus typicalis. The presence of subzones and the difference of the faunas in different districts especially that between the fauna of Holland Patent and the lower Mohawk is pointed out, and the fact brought out (page 36) that the Utica faunules of the Appalachian trough differ from those of the Mohawk valley by the frequent occurrence of Corynoides caliculariS[1] which latter only enters the lower Mohawk valley. The transgression of the Utica shale from the northeast is inferred from the faunal evidence and as corollary of this transgression the conclusion drawn (page 49) that the boundary between the Trenton limestone and Utica shale is not a plane of synchrony, and that the areal restriction of the Corynoides to the lower Mohawk valley may be due to the greater age of the eastern Utica beds and its absence farther west, or to the replacing of the shale by the lower Trenton limestone. The Utica of the Hudson valley is thought to be separated by the Magog shales from the lower Trenton Normanskill shale.

The faunule of the Frankfort shale is described from the supposed Frankfort beds at Waterford and Mechanicville.

In a paper by Grabau on the Physical and Faunal Evolution of North America during Ordovicic, Siluric and early Devonic Time (1909) the relations of the Trenton and Utica are stated as follows:

> The Trenton limestone of America is not a stratigraphic unit, but, as has been repeatedly demonstrated by Ruedemann and noted by many observers, it is the limestone phase of a series which elsewhere is in part or mostly represented by Utica shale. In the Mohawk valley the dividing line between Utica and Trenton is a line constantly rising to the west, the transition being in some cases abrupt, though probably in most cases it is gradual. Ruedemann has pointed out the progressive increase in thickness westward of the limestone, and corresponding decrease in the shale; the former increasing from 40 feet at Saratoga to 430 feet at Utica, and to 954 feet at Rochester, while the latter decreases from 1260 feet to 710 feet to probably zero over the same localities. . . . The

[1] Erroneously there referred to C. curtus.

various sections clearly show that along the western border of the Appalachians, dark graptolite shales continued to form in Upper Ordovicic time, while westward from this the Trenton limestone represents the calcareous phase of the Utica-Trenton series (see map, figure 8).

In a diagram that accompanies Professor Grabau's paper (op. cit. figure 9), the Utica is represented as wholly replaced by Trenton limestone in the latitude of Rochester and farther west.

In the description of the Remsen quadrangle Miller (title 65) has shown the absence of the Dolgeville beds in the area adjoining the Little Falls quadrangle to the west. He found the Utica to be only 300 feet thick indicating a notable thinning to the northwest from the type section. Two hundred feet of Lorraine beds were observed which were found to be destitute of fossils and are not separated by an exact boundary line from the Utica. There is little doubt that these beds are the Frankfort shale. This decrease is in a later bulletin (title 66) by the same author shown to be steady toward the north. It would also become probable from the same paper that the Frankfort shale with a thickness of about 200 feet continues to the northwest and intervenes there between the Utica shale and Lorraine sandstones and shales with the characteristic Lorraine fauna (page 33).

To the south of New York, in New Jersey, Pennsylvania and West Virginia, the shales which formerly were termed "Utica and Hudson River slates" are now known as Martinsburg shale. The Martinsburg shale of the Mercersburg-Chambersburg quadrangle in Pennsylvania has been described by Stose, and fossil lists given by Ulrich (title 61, page 10). The lowest shale fauna is considered as indicating an age corresponding to that of the lower to middle Trenton of New York, and the highest as comprising species characterizing the Eden shale.

Bassler, in his work on the Cement Resources of Virginia (title 62), the Federal Survey's part of which was done under the official direction of Doctor Ulrich, divides the Martinsburg shale in three divisions, namely, upper Trenton shale, Utica shale and Eden shale, representing the shaly Ordovicic deposits of the Appalachian trough. The Martinsburg is continuous from Virginia through Pennsylvania and New Jersey with the shale belt of New York, and this division of the shales has a direct bearing on that of the shale in the New York part of the Appalachian trough, represented by the shales in the Hudson valley.

Schuchert (1910), in his monumental Paleogeography of North America, refers the Utica of New York as the zone of the Mastigograptus fauna to the top of his Ordovicic period. As characterizing the shale facies of the Trenton in the Atlantic province are cited the Climacograptus caudatus, Corynoides curtus and Magog graptolite zones, while the horizon of the Normanskill shale is correlated with the Black River of New York and Kimmswick of Illinois and Missouri. The Frankfort is correlated with the Edenian and placed in the Cincinnatic period, the Ordovicic period being considered as closed by the Utica emergence. Paleogeographic maps of North America in the late Trenton and Utica stages by Ulrich and Schuchert are given, to which we will have occasion to refer.

A new light has been shed on many problems, here involved, in the Revision of the Paleozoic System by E. O. Ulrich (title 68), the first volume of which appeared after this paper was written, but as much of the information therein published was freely given to the author in the joint field excursions in the Mohawk and Hudson valleys, its principles have been applied to a considerable extent to the questions that arose in this investigation and the conclusive answers obtained are clear evidence of the truth of some of these principles. We have here especially in mind Ulrich's theories of a multiplicity of shallow continental seas and of frequent and periodic migrations of faunas from their permanent oceanic habitats into these inland seas.

In the investigation of the Utica and Frankfort shales in the Mohawk valley, the entire mass of shales between the Trenton limestone at the base and the Upper Siluric rocks on the top were studied in the region from Cohoes at the mouth of the Mohawk to the neighborhood of the city of Utica and of Holland Patent. In the lower Mohawk region for the most part a broad plain of deep drift intervenes between the Mohawk river bluffs and the foot of the Helderberg escarpment; only two sets of sections were therefore accessible in greater numbers, one at the base of the shales in the ravines near the mouths of the southern tributaries of the Mohawk and another in the upper Frankfort beds in the ravines cut into the lower slopes of the Helderberg escarpment. The Chuctenunda creek furnished here the most satisfactorily continuous section, leading from the Trenton limestone to the Schenectady beds. The Canajoharie creek and Flat creek at Sprakers afford two excellent sections through the lower " Utica beds " (here distinguished as

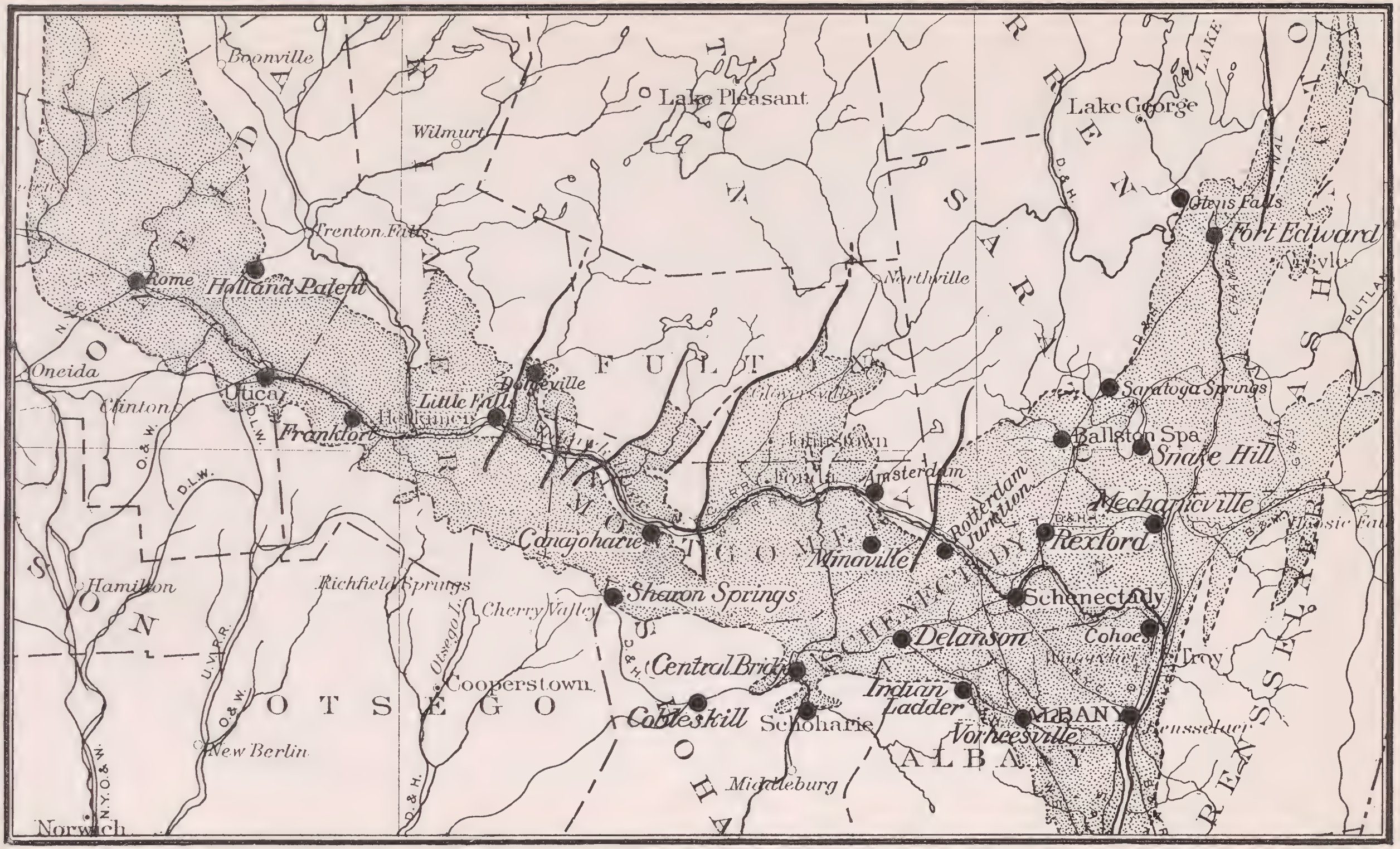

Figure 1 Locality map of the Shale belt in the Mohawk and Upper Hudson valleys. The shale area is shaded.

Canajoharie beds), the East Canada creek one from the Trenton through the transition beds into the lower Utica, while Moyers creek at Frankfort and the "Gulf" at Ilion give excellent sections through the Frankfort shale but fail to show its base. No continuous Utica section has been found in the neighborhood of Utica; the name according to Vanuxem is derived from the exposures in the Starch Factory creek (page 58, "a creek to the east of the city"), now largely within the city. The most important of these sections are here discussed in detail.

"UTICA" SHALE OF AUTHORS[1]

The belt of black "Utica" shale that follows the south side of the Mohawk valley is cut off by the Hoffman Ferry fault, as is well shown in the geologic map of the Amsterdam quadrangle by Prosser, Cumings and Fisher, to be replaced by an area of "Hudson River" or "Frankfort" beds that occupies nearly all Schenectady county and toward the east merges into the zone of folding. Just west of this fault, between Hoffman Ferry and Amsterdam, the south bank of the river is formed by cliffs of Little Falls dolomite and Trenton, above which, according to Prosser and Cumings, the contact of the Trenton and "Utica" is seen in several places, which have been visited by the writer.

In the *Swartztown creek section* (title 45, page 472; title 44, page 457) two feet of black partly noncalcareous, but mostly calcareous shale[2] is exposed overlying very fossiliferous Trenton. The contact in this section which is the first west of the Hoffman Ferry fault is disconformable and the surface of the Trenton irregular. The fossils are:

Corynoides calicularis *Nicholson*
Dicranograptus nicholsoni *var.* parvulus *nov.*
Diplogr. (Mesogr.) mohawkensis *nov.*

A mile farther west is a section opposite Cranesville (title 33, page 653) in which about 21 feet of basal Trenton, overlying the Amsterdam limestone (formerly Black River) with

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[1] It will be shown in this paper that both the Utica shale and Frankfort shale of the lower Mohawk valley are of another, earlier, age than hitherto supposed. They will therefore, in distinction from the true Utica and Frankfort shales, be cited in quotation marks, until differently named.

[2] The "Utica" shale is described as calcareous in distinction from the Frankfort shale. The two have therefore been distinguished by Professor Prosser in the field by the use of the acid bottle.

a little of the calcareous basal Utica shale, is shown. This again contained Corynoides calicularis and Diplogr. (Mesogr.) mohawkensis.

An excellent section of the Trenton and basal "Utica" shale is exposed in *Morphy creek,* (title 33, page 654; title 44, page 460) halfway between Cranesville and Amsterdam and about one and one-half miles west of the preceding section. Here 5 feet of Amsterdam limestone are overlain by 37 feet of Trenton limestone. The uppermost 27 feet are thin, irregular, dark blue, limestone layers with very black shale intercalations. These beds abound in Prasoporas, Trinucleus concentricus, Calymmene senaria, but contain no graptolites. The black calcareous Utica shale follows abruptly with profusely graptolitiferous beds, the species being:

Dicranograptus nicholsoni *var.* parvulus *nov.*
Diplogr. (Mesograptus) mohawkensis *nov.*
Diplogr. *cf.* putillus (*Hall*)
Rafinesquina alternata (*Emmons*) (small)
Leptobolus insignis *Hall*
Orthoceras *sp.*

It follows from this series of outcrops that the Lower Trenton or Prasopora zone at the eastern terminus of the continuous "Utica" belt of the Mohawk valley is separated by a disconformity indicating a small interval of nondeposition, from black calcareous shales characterized by Corynoides calicularis and a characteristic Diplograptus of the Mesograptus group. All three of these ravines reach the drift directly above the basal "Utica" beds and no satisfactory section of the upper "Utica" could be obtained. The latter is found along the south branch of the *Chuctenunda creek,* which empties opposite Amsterdam, and reaches back into the "Frankfort" shale hills, southwest of the village of Minaville where the transition from the "Utica" shale into the "Frankfort" shale is finely exposed in the ravines.

The contact between the Trenton and "Utica" is not shown in the section; the first outcrop is found at the falls of the creek, probably not more than 20 feet above the top of the Trenton. Here were found (Museum locality number 3758):

1	Diplograptus amplexicaulis	(cc)
	Diplograptus (Mesograptus) mohawkensis	(c)
	Lasiograptus eucharis	(r)
	Leptobolus insignis	(r)

[1] cc = very common, c = common, r = rare, rr = very rare.

The next outcrop which furnishes fossils is in a small creek, coming in from the west, at the second bridge above 1, about 220 feet higher in the section. Here were found (Mus. loc. 3759):

2	Corynoides calicularis	(cc)
	Diplograptus foliaceus acutus	(cc)
	Triarthrus becki	(c)

A third fossiliferous outcrop was found along the main Chuctenunda creek one and three-fourths miles west by south, 70 feet above the preceding. This has furnished (Mus. loc. 3760):

3	Diplograptus (Mesogr.) mohawkensis	(cc)
	Lasiograptus eucharis (with colonies)	(cc)
	Leptobolus insignis	(c)
	Triarthrus becki	(r)
	Orthoceras *sp.*	(r)

There follow continuous outcrops for half a mile, all of which contain (Mus. loc. 3761):

4	Diplograptus (Mesogr.) mohawkensis	(cc)
	Lasiogr. eucharis	(cc)

At the end of this series of outcrops, about 30 feet above 3, (Mus. loc. 3762) Lasiograptus eucharis has become by far the prevailing fossil. There occur:

5	Diplograptus (Mesogr.) mohawkensis	(c)
	Lasiograptus eucharis (colonies)	(cc)
	Leptograptus insignis	(r)

A quarter of a mile farther up, beyond the fourth bridge (Mus. loc. 3763) the following fossils were obtained:

6	Diplograptus (Mesogr.) mohawkensis	(c)
	Lasiograptus eucharis	(cc)
	Leptobolus insignis	(r)
	Triarthrus becki	(c)

Three-quarters of a mile farther up, (Mus. loc. 3764), just below the village of Minaville and 300 feet above the first outcrop only

7	Lasiograptus eucharis, and
	Leptobolus insignis

were collected. The next outcrop which is half a mile above Minaville is the base of the Minaville section, described by Cumings

(title 44, page 463). Here in black, slabby calcareous shale were collected (Mus. loc. 3765):

8 Climacograptus *cf.* putillus
Lasiograptus eucharis
Leptobolus insignis

In a gully about one and two-fifths miles south by southwest of Minaville a continuous section 255 feet thick is exposed, which exhibits a complete transition from the typical lithologic character of the "Utica" to that of the "Frankfort." This section has been measured by Cumings and the following lithologic divisions distinguished:

K4 Mostly covered. Thin sandstone and arenaceous shales with a massive 2 foot layer at the base in the head of the glen. 120′ = 540′

K3 Black shales becoming olive to blackish at the top. These shales show a transition from the black calcareous shales of the "Utica" to the arenaceous, thin, crumbling shales of the "Hudson River" stage. 165′ = 420′

K2 Top consisting of slaty layers containing graptolites in abundance. Black, even shale. 90′ = 255′

K1 Mostly covered, but showing brown in weathering, slabby shale in the west bank of Chuctenunda creek, just above Minaville. 165′ = 165′

While K1 of this section has furnished the faunule cited under 8, the following division K2 was found to contain still, at least in its lower part (Mus. loc. 3770), specimens of

9 Diplogr. (Mesogr.) mohawkensis

Near the top (Mus. loc. 3769) a zone appears that is characterized by

10 Climacograptus spiniferus (cc)
Lasiograptus eucharis

K3 proved fossiliferous in one part (Mus. loc. 3768) where

11 Climacograptus spiniferus

occurs in great profusion.

The shales in this division, although still carbonaceous and very black like the "Utica" shale, do not any more react with HCl and are not calcareous.

K4, which consists prevailingly of thin sandstone and arenaceous shales of "Frankfort" aspect, still contains bands of black argillaceous shale, which usually yield graptolites on examination. At the base (120 feet from the top sandstone layer of the section) a band (Mus. loc. 3767) has furnished:

12 Climacograptus typicalis (c)
Lasiograptus eucharis (cc)

The Lasiograptus eucharis occurs in an unusually large and broad mutation.

Another graptolite horizon was found but 22 feet from the top (Mus. loc. 3766). This contains:

13 Diplograptus (Amplexograptus) macer nov. (c)

The graptolite that characterizes this fauna is an extremely narrow and long form, hitherto not observed at other horizons and therefore here distinguished by a new specific term (see Paleontologic notes, p. 82).

A survey of these localities as little suggests any sharp faunal boundaries as do the lithologic characters of the rocks. The rock is a black brownish weathering shale that strongly reacts with HCl. This character does not change until K3 (with horizon 11) is reached, when the black shale becomes wholly argillaceous. Nevertheless there is distinct though gradual change in the faunal aspect of the Utica shale as one passes upward. The basal beds at Morphy's and Swartztown creeks were found to be characterized by Corynoides calicularis and Diplograptus mohawkensis, two fossils which are wholly foreign to the Utica beds of the Utica section, or to the typical Utica beds. Corynoides calicularis is in the Chuctenunda section still abundantly found 220 feet above the base. Diplograptus mohawkensis remains the most common fossil, much longer, through 3 and 4, but in 5 it is replaced by Lasiograptus eucharis which remains the dominant graptolite to near the beginning of the transition beds, where it is somewhat abruptly displaced by Climacograptus spiniferus, (in 10) which hitherto had not been observed in the section. Then also Climacograptus typicalis appears and at the top a new species of Diplograptus. We may add that Lasiograptus eucharis, Climacograptus spiniferus and Climacograptus typicalis continue into and through the "Frankfort" shale in the lower Mohawk valley.

We can then distinguish three larger faunal zones, namely:

1 That of Diplograptus mohawkensis
Corynoides calicularis
2 That of Lasiograptus eucharis
3 That of Climacograptus spiniferus
Climacograptus typicalis
Diplograptus macer

All three of these zones are absent in the typical Utica section.

Another series of sections through the "Utica" shale, or at least its lower part, is afforded by the gulfs of Flat creek at Sprakers and of Canajoharie creek at Canajoharie. These places are about 20 miles west of the Chuctenunda sections and halfway between the latter and the typical Utica section of the Utica region.

The *Canajoharie creek and Sprakers sections* have been briefly described by Prosser and Cumings (title 33, page 638). They record at the former 53+ feet of Tribes Hill (Fucoidal) limestone, underlying 17 feet of thin bedded dark blue, very fossiliferous Trenton limestone with shaly partings. A distinct unconformity separates the two. About 300 feet of very black, bituminous slate referred to the lower "Utica" formation were found in the glen. The following fossils are cited from the Trenton:

1	Rafinesquina alternata (*Con.*), *Hall and Clarke*	(c)
2	Calymmene callicephala *Green* (?)	(r)
3	Orthis (Dalmanella) testudinaria *Dalm.*	(a)
4	Asaphus platycephalus *Stokes*	(c)
5	Monticulipora (Prasopora) lycoperdon *Say.*	(r)
6	Modiolopsis mytiloides *Hall* (?)	(rr)
7	Tellinomya levata *Hall*	(rr)
8	Zygospira recurvirostris (*Hall*), *Winch. and Schuch.*	(rr)
9	Plectambonites sericeus (*Sowb.*), *H. and C.*	(c)
10	Trinucleus concentricus *Eaton*	(r)
11	Atrypa (Protozyga) exigua *Hall*	(rr)
12	Ceraurus pleurexanthemus *Green* (?)	(rr)
13	Murchisonia bellicincta *Hall*	(rr)
14	Murchisonia gracilis *Hall* (?)	(rr)
15	Camarella *cf.* volborthi *Bill.*	(rr)
16	Stictopora *sp.*	(r)

and the following from the "Utica" which is stated to contain a larger number of fossils than has been found in the more eastern exposures:

1	Lingula quadrata (*Eich.*), *Hall* (?)	(c)
2	Plectambonites sericeus (*Sowb.*), *H. and C.*	(a)
3	Orthis (Dalmanella) testudinaria *Dalm.*	(c)

4	Triarthrus becki *Green*	(c)
5	Graptolites	(a)
6	Asaphus platycephalus *Stokes*	(r)
7	Tellinomya nuculiformis *Hall*	(r)
8	Pterinea trentonensis (*Conrad*)	(rr)
9	(?) Edmondia subtruncata (*Hall*)	(rr)
10	Endoceras proteiforme *Hall*	(c)
11	Raphistoma lenticulare (*Emmons*)	(r)
12	Trocholites ammonius *Conrad*	(r)
13	Rafinesquina alternata (*Con.*), *H. and C.*	(r)
14	Orthis (Dinorthis) pectinella *Emm., var.* semiovalis, *Hall*	(rr)
15	Crinoid segment	(rr)
16	Leptobolus insignis *Hall*	(r)
17	Lingula curta *Con.*	(a)
18	Monticulipora (Prasopora) lycoperdon *Say.*	(rr)
19	Bellerophon *sp.*	(rr)

With the exception of a bed of compact barren limestone at the base, which has an irregular surface and is separated by an unconformity from the overlying beds, the Trenton is composed of thin beds of limestone alternating with layers of shale of equal thickness, the whole having a distinctly transitional character like the beds designated as *Dolgeville beds* by Cushing. A limestone near the base is a shell-breccia and contains the brachiopods and trilobites cited by Prosser. This is followed by a thin bryozoan reef, from which Doctor Ulrich has identified:

Stictoporella *cf.* angularis *Ulrich*
S. exigua *Ulrich*
Phaenopora incipiens *Ulrich*
Pachydictya acuta (*Hall*)
P. pumila *Ulrich*
Eridotrypa mutabilis *var.* minor *Ulrich*

A small reef of broken shells swept up by a current, passes through the shaly Trenton limestone. This is especially rich in fossils and has furnished (*fide* Doctor Ulrich):

Corynotrypa inflata (*Hall*)
Atactoporella ? crassa *Ulrich*
Stomatotrypa ? *sp.*
Eridotrypa mutabilis *var.* minor *Ulrich*
Phylloporina reticulata (*Hall*)
Nematopora ovalis *Ulrich*
Arthroclema pulchellum ? *Billings*
Rhinidictya canadensis *Ulrich*
Pachydictya acuta (*Hall*)

P. pumila *Ulrich*
Stictoporella *cf.* angularis *Ulrich*
S. exigua *Ulrich*
Phaenopora incipiens *Ulrich*
Dalmanella futilis (*Sardeson*) *var.*
Rhynchotrema increbescens (*Hall*)
Eurychilina subradiata *Ulrich var.*
Calymmene senaria *Conrad*
Pterygometopus callicephalus (*Hall*)
Trinucleus concentricus (*Eaton*)

The shaly intercalations have afforded us:

Rafinesquina alternata (*Emmons*)	(c)
Leptobolus insignis *Hall*	(c)
Lingula curta (*Conrad*)	(c)
Dalmanites (Pterygometopus) callicephalus *Hall*	(r)
Diplograptus amplexicaulis *Hall*	(cc)
Diplograptus (Mesogr.) mohawkensis	(c)
Corynoides calicularis *Nicholson*	(r)
Ctenodonta *cf.* nuculiformis *Hall*	(r)
Ulrichia ? bivertex *Ulrich*	(c)
Primitiella unicornis *Ulrich*	(r)
Small ostracods of Primitia type	

It will be noted that the shaly intercalations of the Trenton limestone contain two of the most characteristic graptolites cited above from the basal "Utica" shale in the neighborhood of Amsterdam. Likewise it will be seen that also in the Canajoharie section these graptolites and all the other fossils observed in these shaly intercalations go up into the black "Utica" shales.

The fauna of both the limestone and the shaly intercalations is of earliest or basal Trenton age.

This belt of basal Trenton limestone with the underlying Amsterdam limestone can be traced by outcrops, rather widely separated through the faulting of the region, around the southeast side of the Adirondacks to Saratoga and Glens Falls. Since these beds are lower than any exposed at Trenton Falls, their reference to the Trenton is likely to lead to confusion and they should be recognized by a distinct name. For a time we have termed them the Jacksonburg limestone, but since the latter unit, recognized in New Jersey (title 59), also comprises beds of Amsterdam and Lowville age, it is not properly applicable to the limestone in question. As the latter is best exposed at Glens Falls with the underlying Amsterdam (Black Marble) limestone and overlying Canajoharie shale, we propose for it the term *Glens Falls limestone*.

The first 65 feet of the beds at Canajoharie (from the Glens Falls limestone to the lower falls) consist of calcareous shale with frequent small limestone seams near the base. The shale is deep black, calcareous, hard and splintery, brownish weathering. It contains:

Diplograptus amplexicaulis *Hall*	(cc)
Leptobolus insignis *Hall*	(c)
Schizocrania filosa *Hall*	(c)
Lingula curta *Conrad*	(c)
Calymmene senaria *Conrad var.*	(c)
Ctenodonta nuculiformis ? *Hall*	(r)
Primitiella unicornis *Ulrich*	(r)

An extremely rich zone was observed in the cliff directly above the falls (65–120 feet from base). This has furnished:

Diplograptus amplexicaulis (*Hall*)	(cc)
Corynoides calicularis *Nicholson*	(c)
Diplograptus (Mesograptus) putillus *Hall*	(r)
Lasiograptus eucharis (*Hall*)	(c)
Sponge spicules	
Spatiopora *sp.*	
Leptobolus insignis *Hall*	(c)
Lingula curta *Conrad*	(r)
Dalmanella testudinaria (*Dalman*)	(c)
Rafinesquina alternata (*Emmons*) small	(c)
Plectambonites sericeus (*Sowb.*) H. & C.	(c)
Hyolithes pinniformis *nov.*	(c)
Prolobella ? trentonensis (*Hall*)	(c)
Pterinea insueta[1] (*Emmons*)	(r)
Ctenodonta *cf.* nuculiformis (*Hall*)	(c)
Clidophorus *sp.*	(c)
Ctenodonta *sp. nov.* large	(rr)
Whiteavesia *sp.*	
Clathrospira subconica (*Hall*)	(c)
Liospira *cf.* rotuloides (*Hall*)	(c)
Orthoceras *sp.*	(r)
Calymmene senaria (*Conrad*)	(cc)
Lepidocoleus jamesi (*Hall & Whitfield*)	(c)
Turrilepas filosus *Ruedemann*	(r)
Ulrichia ? bivertex *Ulrich*	(c)
Primitiella unicornis *Ulrich*	(cc)
Minute Primitias	

[1] This last species, described by Hall in Paleontology New York, 1:291, is known only from this locality. Hall states of it: "This species occurs in the lower black shale, or Utica slate, at Canajoharie, and is known in the higher part of the group."

A third series of outcrops begins with a cliff on the north side of the creek, about 115 feet above the base and reaches to 150 feet. The shales of this are lithologically identical with the underlying rock. These beds contain:

Cyathodictya ? tubularis *nov.*	(cc)
Glossograptus quadrimucronatus *mut.* cornutus *Rued.*	(c)
Diplograptus (Mesograptus) putillus *Hall*	(cc)
Lasiograptus eucharis (*Hall*)	(r)
Spatiopora *sp.*	(r)
Leptobolus insignis *Hall*	(c)
Lingula curta *Hall*	(c)
Rafinesquina alternata (*Emmons*)	(r)
Orthoceras *sp.*	(r)
Ulrichia ? bivertex *Ulrich*	(c)
Primitiella unicornis *Ulrich*	(c)

The most novel element of this association is Glossograptus quadrimucronatus mut. cornutus. This characteristic form has before been known to us only from the Rural Cemetery beds near Albany which we had referred in Bulletin 42 to the Utica. It is there associated with Diplogr. (Mesogr.) putillus and Corynoides calicularis. It is safe to infer on the strength of this form that the Rural Cemetery beds and this portion of the Canajoharie beds belong to the same horizon. Some layers are profusely covered with the problematicum termed here Cyathodictya? tubularis. This fossil is described in the paleontologic notes at the end of this paper.

The fourth series of beds is exposed in a cliff reaching from 150 feet above the base to about 270 feet. These beds contain:

Cyathodictya ? tubularis *nov.*	(c)
Corynoides calicularis *Nicholson*	(cc)
Glossogr. quadrimucronatus *mut.* cornutus *Rued.*	(cc)
Diplograptus (Mesogr.) putillus *Hall*	(cc)
Prasopora simulatrix *Ulrich*	(c)
Lingula curta *Hall*	(c)
Triarthrus becki *Green*	(cc)
Calymmene senaria *Conrad*	(r)
Ulrichia ? bivertex *Ulrich*	(c)

Triarthrus becki, which before had not been noticed, appears in this last division about 40 feet from the base in great numbers. Glossograptus quadrimucronatus mut. cornutus and Corynoides calicularis

were found near the top of this last cliff with which end the outcrops in the Canajoharie gulf.

A series of exposures which to a large degree is complementary to the one just described is afforded by the *Flat creek ravine at Sprakers,* two and one-half miles east of the Canajoharie ravine.

The Glens Falls limestone is finely exposed in this section. It is 17 feet thick and consists of thin layers of very fossiliferous limestone with shale intercalations near the top and a two-inch conglomeritic layer at the base, separating it from the Tribes Hill (Fucoidal) limestone. The limestone beds exhibit large ripple marks, small piles of current-swept pebbles and other signs of shallow water conditions. Besides the fossils noted from the Canajoharie beds, Eurychilina subradiata was also collected.

The "Utica" shale comes in, notwithstanding the shaly intercalations of the upper Glens Falls beds abruptly as a black shale formation. It contains directly at the base:

Diplograptus amplexicaulis (*Hall*)	(cc)
Ctenodonta *cf.* nuculiformis (*Hall*)	(c)

1 Ten feet above the base abundant Diplograptus (Mesogr.) putillus and ostracods (Ulrichia ? bivertex, Primitiella unicornis, Primitia) were observed, which continued through 20 feet, where also layers with great numbers of Leptobolus insignis and limestone bands filled with Dalmanella testudinaria were observed.

2 The beds from 30–60 feet above the base furnished:

Diplograptus amplexicaulis	(cc)
Cyathodictya ? tubularis	(cc)
Leptobolus insignis	(cc)
Ctenodonta *cf.* nuculiformis	(c)

3 From 60 feet above base upward there were observed besides:

Diplograptus amplexicaulis	(cc)
Orthoceras *sp.*	
Lingula curta	(c)

4 75 feet above base besides Diplograptus amplexicaulis and the ostracods, specimens of Clathrospira subconica (Hall) were found.

5 From 110–20 feet Calymmene senaria occurs in great abundance and from 125–30 feet fragments of Isotelus and Prasoporas fill the beds. Also at about 135 feet above the

base is a bed of abundant small Prasoporas. It is important that this Prasopora, forming here an horizon, has been recognized by Doctor Ulrich as the lower Trenton Prasopora simulatrix.

6 Directly above this bed Triarthrus becki begins to be observed in considerable numbers and it continues to be the common fossil through a considerable thickness.

7 From 160–80 feet Triarthrus becki and Corynoides calicularis are the dominant fossils, while

8 At 210 feet above base Lasiograptus eucharis appears in great numbers and typical expression. It is associated with:

Triarthrus becki, and
Lingula curta

This association was observed to the top (230 feet) approaching which were found:

Sphenothallus angustifolius *Hall*[1]	(cc)
Dalmanella testudinaria (*Dalm.*)	(cc)
Schizocrania filosa *Hall* (in large specimens)	(c)
Trocholites ammonius *Hall*	(c)
Orthoceras *sp.*	(c)

This congeries is typically that observed in the lower "Utica" shale in the East Canada creek section at Dolgeville and it is notable that also the lithic character of the light drab weathering, blocky, polygonal breaking, thick-bedded mud-shale is the same as that prevailing in much of the lower parts of the shale at Dolgeville. We consider it therefore probable that the top of this section is equivalent to the lower part of the Dolgeville "Utica."

In a new road cut between Flat creek and Canajoharie about 340 feet above base of "Utica," hard and thin-bedded black shale was found, containing:

Climacograptus spiniferus (filling one bed)	(cc)
Leptobolus insignis	(c)
Triarthrus becki	(c)

Another road cut 40 feet higher and to the north of the former furnished again abundant:

Climacograptus spiniferus	(c)
Diplograptus vespertinus[2]	(cc)

This shale is very strikingly dark and light banded.

[1] *See* Paleontologic notes, p. 74.
[2] *See* Paleontologic notes, p. 83.

The heavy drift to the south has buried the "Utica" beds as far as the "Frankfort" beds at the base of the Helderberg escarpment.

If we combine the observations of Canajoharie and Flat creeks, we obtain the following groups of faunules, indicative of larger zones:

1 Zone of Diplograptus amplexicaulis, Corynoides calicularis, ostracods, lamellibranchs (notably Pterinea (Prolobella?) trentonensis and insueta, etc.).

2 Zone of Glossogr. quadrimucronatus cornutus, Corynoides calicularis, the ostracods, Cyathodictya, Triarthrus becki.

3 Zone of Lasiogr. eucharis, Lingula curta, Schizocrania filosa, Trocholites ammonius, Triarthrus becki.

4 Zone of Climacogr. spiniferus, Diplogr. vespertinus, Lasiogr. eucharis, Triarthrus becki

The first two zones have never, in our earlier work, been observed in the Dolgeville section, while the base of that latter section has furnished us a faunule identical with that of number 3. To be sure of the absence of the lower two zones in the Utica region, we have carefully searched the basal sections of the Utica at Dolgeville and Jacksonburgh, three miles west of Little Falls, where Cushing's map shows an exposure of the contact of Dolgeville (transition) beds and Utica shale; along the Starch Factory creek at Utica; and the exposure between Holland Patent and South Trenton, recorded by Miller. In none of these localities were any traces of the first two zones of the Canajoharie section found. On Nine Mile creek near South Trenton, where the contact of the Trenton and true Utica is exposed, Climacograptus typicalis is the dominant and characteristic graptolite of the basal Utica. This typical Utica graptolite occurs there in immense multitudes. It is associated with:

Mastigograptus simplex (*Walcott*)
M. tenuiramosus (*Walcott*)
Pleurograptus linearis (*Carruthers*)
Leptograptus annectans (*Walcott*)
Dicranograptus nicholsoni *Hopkinson*
Glossograptus quadrimucronatus (*Hall*), short, long spined variety
Cyathophycus reticulatus *Walcott*

This is the *characteristic fauna of the base of the typical Utica.* It is the Mastigograptus fauna of Schuchert (1910, p. 529). Lasiogr. eucharis appears in great numbers nearby (at Floyd and Marcy) and a little higher up.

In the Dolgeville and Jacksonburgh sections which lie halfway between Utica and Canajoharie, the base of the "Utica" shale (above the Dolgeville transition beds) shows no trace yet of the Canajoharie faunule, but contains:

Glossograptus quadrimucronatus
Climacograptus typicalis
Lasiograptus eucharis
Lingula curta
Schizocrania filosa

The dominant Climacograptus typicalis of the true Utica is found but sparingly, and Leptograptus annectans, Pleurograptus linearis, Dicranograptus nicholsoni and the Mastigograpti are not observed at all in the bed. It is therefore probable that the basal "Utica" at Dolgeville-Jacksonburgh and that at Utica do not represent the same horizons, and if so, the former is probably older than the latter.

From the assemblage of the facts here presented, we infer that at Canajoharie the two lower zones surely and the others most probably lie below the base of the true Utica and correspond in age to some part of the Trenton. For this older black shale of the Mohawk valley we propose the term *Canajoharie shale.* This stage is characterized by the following species:

Corynoides calicularis
Diplograptus amplexicaulis
Diplogr. (Mesogr.) mohawkensis
Glossograptus quadrimucronatus *var.* cornutus
Pterinea (Prolobella) trentonensis
P. insueta
Ulrichia? bivertex
Primitiella unicornis

All these are unknown to us from the Utica shale. A number of forms as Lasiogr. eucharis, Diplogr. putillus, Triarthrus becki, appear in the Canajoharie beds rarely, but become dominant forms in the Utica shale, and others, as the shale brachiopods Leptobolus insignis and Lingula curta, are equally common to both. The true Climaco-

graptus typicalis has not been seen in the Canajoharie beds, but is a most characteristic and common graptolite of the Utica beds.

A peculiar feature which we are at present unable to explain is the very frequent occurrence of Diplogr. (Mesogr.) mohawkensis in the Canajoharie beds in the Amsterdam sections and its apparent absence in the Canajoharie sections. Since it is not restricted there to the basal beds only, it can not be assumed that it represents still a lower horizon not represented at Canajoharie.

If the Canajoharie shale is older than the true Utica, it corresponds in age to some part of the Trenton. The question then arises, How much of the Trenton does it represent? The fossils of the underlying Trenton and transition shale at Canajoharie (see page 21) are those of the basal Trenton only, and this alone is represented by limestone in the lower Mohawk valley,[1] where it rests on the Amsterdam limestone. The lower Trenton, which is characterized by the Prasopora simulatrix zone and its base by the fauna of the Nematopora beds, is apparently at Canajoharie merged already in the Canajoharie formation, as the occurrence of a horizon with Prasopora simulatrix, rather high up in the Canajoharie beds in Flat Gulf (page 26) and the evidence of the bryozoan reefs at the base of the Canajoharie would indicate. The Canajoharie beds correspond therefore to at least the lower Trenton. What proportion, if any, of the middle Trenton is included can not be determined with the data at hand. The typical Canajoharie fauna at Canajoharie indicates as old Trenton as the oldest in the Trenton Falls section. Possibly it contains only lower Trenton but probably it belongs in large part between the lower and middle Trenton.

The true Utica is, from present evidence, entirely absent in the lower Mohawk region. We infer this from the faunas of the Canajoharie shale indicating Trenton age and further from the facts that these black shales pass gradually (as in the Minaville section) into the so called "Frankfort" or "Hudson River" shales and sandstones of the lower Mohawk valley and that these latter have proved to be of an age older than upper Trenton (see Schenectady formation, page 37).

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[1] This conclusion had also been reached by Cumings (title 44, p. 466).

The writer has before cited faunules from the Hudson valley which contain the characteristic elements of the Canajoharie beds. The most important of these is that from the Rural Cemetery of Albany, whence Glossogr. quadrimucronatus mut. cornutus was described. It is there associated with

Mastigograptus circinalis *Rued.*
Corynoides calicularis *Nicholson*
Lasiograptus eucharis (*Hall*)
Diplogr. putillus (*Hall*)
Eopolychaetus albaniensis *Rued.*
Pontobdellopsis cometa *Rued.*
Leptobolus insignis *Hall*
Schizambon ? fissus *var.* canadensis *Ami*
Hormotoma *cf.* gracilis (*Hall*)[1]

This is one of the various upper subzones of the "Hudson River shales" which in the former publications (op. cit. page 36) we have referred to as an eastern development, characteristic of the Appalachian trough, of the Utica shale.

The belt of Canajoharie beds in the lower Mohawk valley is abruptly cut off by the Hoffmans Ferry fault which, since the eastern side has dropped, has buried all lower beds east of the fault, under a belt of "Frankfort" shales and sandstones extending from the town of Galway in the north across the Mohawk river to the foot of the Helderbergs. It becomes evident, however, from the facts cited above, that the Canajoharie beds reappear from under this thick mass of overlying "Frankfort" shales on the east, along the Hudson, through the Taconic-Green Mountain folding and they strike there according to this folding to the north-northeast, as indicated by the outcrops at the Rural cemetery and at Cohoes.

The stations which we had cited in Bulletin 42 as representing the Utica shale and forming a belt that passes through Albany, are now mostly to be considered as Canajoharie beds, the same as the occurrence at the Rural cemetery, and the few remaining like that at Black creek, Voorheesville and the Vly at Voorheesville (title 47, pages 531–33) are black shale zones intercalated in sandstones and correspond to the "Frankfort" rocks about Schenectady. We must infer from these facts that typical Utica is not represented in the Hudson River region but that the Canajoharie shale is directly followed by the "Frankfort" (Schenectady) beds.

[1] *See* title 47, p. 528; title 60, p. 37.

This is, among others, suggested by an outcrop at Crescent, at the last bend of the Mohawk. At the latter place an anticline brings to the surface (thereby causing the rapids in the river) about 50 feet of "bluestone" (a calcareous sandstone) of the type characteristic of the "Frankfort" (Schenectady) beds, in beds 2–3 feet thick with intercalations of black shale. The latter, however, do not furnish the "Frankfort" faunule, noted in a later chapter, but

Corynoides calicularis *Nicholson*
Cf. Azygograptus ? simplex *Rued.*
Diplograptus putillus *Hall*
Climacograptus bicornis *Hall*
Diplograptus *cf.* angustifolius *Hall*
Leptograptus annectans *Walcott* (narrow form)

This congeries of forms contains on one hand the Corynoides on account of which we refer the beds to the Canajoharie formation, a reference which is supported by the close position of the outcrops to the belt of Canajoharie beds at the mouth of the Mohawk. It also contains Leptograptus annectans, a species that to our knowledge has been found hitherto only in the basal Utica beds in the neighborhood of Trenton, N. Y., and in the true Utica beds of Cincinnati (title 61, page 265) but the form representing this species at Crescent is not strictly the same as the typical Holland Patent type. The lithologic features of this interesting outcrop also indicate the fact that in the east, the upper portion of the Canajoharie formation may assume the lithologic character of the "Frankfort" (Schenectady) beds, a fact that would argue for a direct succession of the two formations in this region.

While the Canajoharie shale is eastward in the Mohawk valley cut off by the Hoffman's Fault, we have found it to reappear north of Schenectady along Alplaus creek and thence the black shales can be traced past Ballston Spa, Saratoga and along the edge of the Precambric to Glens Falls, where they are again cut out by faults. The locality on Alplaus[1] creek has afforded:

Corynoides calicularis
Glossograptus quadrimucronatus *mut.* cornutus
Lasiograptus eucharis
Leptobolus insignis
Orthoceras hudsonicum *nov.*[2]

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[1] A curious distortion of the old German locality name "Aalplatz," eel-place.

[2] This species retains in pyritized condition the protoconch and nepionic portion of the shell. See note, p. 113.

There can be no doubt of the Canajoharie age of the rock of this outcrop, and yet it is only two miles due north of the "Frankfort" outcrops of Rexford Flats, leaving but a narrow strip for a possible belt of intervening Utica shale; and considering the very slight southwest dip of the rocks also but little room for any thickness of the Utica shale.

Fine exposures of these Canajoharie shales were observed about Ballston Spa, especially along Kayaderosseras creek. Here occur:

Dicranograptus nicholsoni (rr)
Glossograptus quadrimucronatus (in some beds large and typical) (r)
Climacograptus spiniferus (cc)
Lasiograptus eucharis (r)

A similar faunule was observed on the Glowegee, northwest of Ballston Spa, while the single outcrop at Saratoga (Carlsbad Spring) contains:

Climacograptus spiniferus
C. mohawkensis
Lasiograptus eucharis
Leptobolus insignis

An excellent outcrop of the Canajoharie beds between Saratoga and Glens Falls is that at the falls of the Snook kill at Gansevoort, where occur:

Glossograptus quadrimucronatus *mut.* cornutus
Diplograptus mohawkensis
Lasiograptus eucharis

Very important exposures were found above and below Glens Falls. Those above are near the feeder dam, one to two miles southwest of the city and contain:

Corynoides calicularis
Diplograptus amplexicaulis
Glossograptus quadrimucronatus
Leptobolus insignis
Pontobdellopsis cometa
Orthoceras *nov. cf.* amplicameratum
Triarthrus becki

Between Glens Falls and Hudson Falls (formerly Sandy Hill) the contact between these shales and the basal Trenton limestone can be observed — or rather could be observed — the feeder dam between the paper mills and the mill races on both sides having

rendered inaccessible the contact exposed in the river bed. This contact was recorded by Mather (title 2, p. 394) as follows:

> At a little distance below the ferry on the Saratoga shore, at and near the sawmill, the junction of the slate and Trenton limestone, and the gradation of one into the other by interstratification, with the numerous and beautiful fossils, which are intermingled near their junction, can easily be examined when the river is low. The trilobite, the Nuttainia concentrica of Eaton [Trinucleus concentricus (Eaton)], is extremely abundant, and on one specimen of a thin band of limestone six inches square, from the slate, were no less than ten of these trilobites, some of which were entire, and one of the Triarthrus becki.

While these transition beds can not be seen any more in place, the construction of the mill race for the Fenimore Paper Mill opposite Hudson Falls has brought to light a great quantity of the transitional rock which has been dumped along the river bank just above the mill. It consists of dirty grayish-brown limestone with black shale seams. The limestone is very fossiliferous; the following fossils have been noted:

Mesotrypa quebecensis (*Ami*)
Schizocrania filosa *Hall*
Dalmanella testudinaria (*Dalman*)
Plectambonites sericeus (*Sow.*)
Triarthrus becki *Green*
Trinucleus concentricus (*Eaton*)
Isotelus fragments

The shales at the falls contain:

Corynoides gracilis *Hopkinson*
Diplograptus amplexicaulis *Hall*
Climacograptus spiniferus *Ruedemann*
Lasiograptus eucharis (*Hall*)
Trocholites ammonius *Conrad*

These shales can thence be followed about two miles through a fine gorge to the falls at Fort Edward, where there are found:

Corynoides calicularis *Nicholson*
Diplograptus *cf.* euglyphus *Lapworth*
Trematis terminalis (*Conrad*) ?
Orthoceras arcuolineatum *nov.*

From Fort Edward this belt of shale can be followed down the Hudson river for several miles. Occasionally, as in an outcrop two

miles south of the mouth of the Snook kill, limestone bands one to two inches thick appear, which are entirely composed of brachiopod, trilobite and crinoid fragments, but collecting will not furnish anything but the common brachiopods Dalmanella testudinaria, Rafinesquina, Plectambonites sericeus and the trilobite Trinucleus concentricus. The surrounding shales contain: Corynoides calicularis, Climacograptus spiniferus, C. putillus, Lasiograptus eucharis. The last mentioned form was also observed to fill a band of black shale about three miles up the Snook kill, where it is associated with Trocholites ammonius.

The following inferences in regard to this belt of black shales in Saratoga county seem of importance for the present inquiry:

1 These shales which have hitherto been considered as good typical Utica shales, are in their lithologic aspect like the latter but lack the strong calcareous admixture and for that reason rarely effervesce with acid. But, as we shall show later, they are lithologically quite distinct from the belt of Snake Hill beds, which adjoin them to the east, the latter containing not only numerous intercalations of grit and sandstone beds, as at Snake hill, but being also thinner bedded, more fissile, more argillaceous and less carbonaceous, approaching in their character the Frankfort shale.

2 The fauna of these shales is that of the Canajoharie beds of the Mohawk valley, as shown by the occurrence of and dominance of Corynoides calicularis, Diplograptus amplexicaulis, Glossograptus quadrimucronatus mut. cornutus, Lasiograptus eucharis.

3 These shales rest also in this belt on the basal Trenton (Glens Falls) limestone. This relation was observed, as above stated, at Hudson Falls. It may also be inferred from the outcrops on the Glowegee west of Saratoga, which lie but a short distance south and in the dip of the belt of basal Trenton (Glens Falls) limestone passing west of Saratoga through Rowland's mill and Rock City Falls.

FRANKFORT SHALE

The type locality of the Frankfort beds is the gorge of Moyer creek at Frankfort, about nine miles southeast of Utica. A parallel series of fine outcrops is furnished by Steels creek, only two miles away, in the so-called Ilion gulf.

Investigations of these two sections have shown that both lack the base or the contact with the Utica beds. A comparison with the sections of Starch Factory and Ferguson creeks near Utica indicates that the Frankfort and Ilion sections begin closely above the Utica shale. This is also evident from the fact that on the other side of the Frankfort section only two miles to the east, the Utica shale is still exposed on Fulmer creek south of the village of Mohawk. The strike of the shale in the latter outcrop will carry it to very near the base of the Frankfort and Ilion sections.

We found in the rock section at Frankfort which by aneroid is 305 feet thick,[1] four bands of shale containing fossils. The first of these was collected 15 feet above the base of the section at the foot of a cliff 60–70 feet high.

1 Climacograptus typicalis *Hall*
Lingula fragment
Leptobolus insignis *Hall*
Camarotoechia *sp.*
Orthoceras *sp.*
Triarthrus becki *Green*
Trinucleus concentricus (*Eaton*)

The next fossiliferous band was found about 85 feet above the base at the second bridge over the creek. Here were obtained:

2 Climacograptus typicalis *Hall* (large specimens)
Prasopora *sp.* (minute colony)
Leptobolus insignis *Hall*
Dalmanella testudinaria (*Dalman*) *mut.*
Rhynchotrema inaequivalve (*Castelnau*)
Modiolopsis *sp.* (fragment)
Orthoceras *sp.* (septum)
Triarthrus becki *Green*
Trinucleus concentricus (*Eaton*)

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[1] Since these beds dip toward the southwest with an angle that locally is 5°, but in general not more than 2°, it is obvious that this figure is too small. Cushing (1905, p. 36) has determined the surface of the Beekmantown to fall from Middleville to Ilion at a rate of somewhat over 100 feet a mile, stating that the line of greatest dip runs somewhat more to the westward of this direction. This line of greatest dip would then come near the direction of the Frankfort section and since a fall of 100° in a mile corresponds to but 1° of dip, while the average dip in the Frankfort section appears to be perhaps twice as much, it is safe to assume that at least 200 feet should be added, but probably a thickness of between 200 and 370 feet, the latter figure corresponding to a dip of 2°.

At about the same level is the black shale at the base of the Ilion section (230 feet below the Oneida conglomerate), which has furnished:

Climacograptus typicalis *Hall*
Leptobolus insignis *Hall*
Dalmanella testudinaria (*Dalman*) *mut.* (small)
Dinorthis pectinella (*Emmons*)
Rhynchotrema inaequivalve (*Castelnau*)
Cf. Serpulites longissimus *Murchison*
Triarthrus becki *Green*

No fossils were observed until about 240 feet above the base, where occur:

3 Leptobolus insignis *Hall*
Orthoceras *sp.*

The last fossiliferous shales were found directly below the top (280–305 feet). They furnished:

Climacograptus typicalis *Hall* (c)
Orbiculoidea tenuistriata *Ulrich* (*fide Ulrich*)
Leptobolus insignis *Hall*
Orthoceras (fragment)
Triarthrus becki *Green*

Of these fossils the Orbiculoidea tenuistriata and the Triarthrus becki were found in the shale directly below the Oneida conglomerate.

It is obvious that these small faunules lack the essential elements of the Lorraine fauna and do not appear to consist of more than an impoverished Utica fauna. We see the strongest evidence of the close faunistic relation between the Utica and Frankfort periods in the uninterrupted persistence of Climacograptus typicalis through the whole of the Frankfort shales.

As it will be shown in the next chapter that the beds in the lower and probably middle Mohawk valley which have been hitherto referred to the Frankfort are of much older age, the Frankfort formation disappearing eastward by overlap and the relations of the typical Frankfort beds of the Frankfort section westward and northward have not yet been studied in detail, it becomes necessary to restrict for the present the term Frankfort shale to the formation as exposed in the Utica region. The formation thus restricted has its basal limit defined by the top of the true Utica, while the upper boundary, which in the Utica region is formed by the Oneida con-

glomerate, is not yet well defined in regard to the Pulaski formation, the question being to which of the two the shale with Trinucleus northwest of Utica is to be referred. Doctor Ulrich writes that he is inclined to place it with the Frankfort and to confine the Pulaski to the overlying even more fossiliferous arenaceous limestone and shale shown at Pulaski and in the upper part of the Lorraine gorge.

The problem of the correlation of the Frankfort formation, thus restricted and defined, with the strata of Ohio has been discussed very fully by Doctor Ulrich and the author. Doctor Ulrich recognizes in the Frankfort s. str. the two middle divisions of the Eden shale at Cincinnati, but he is convinced that it also includes the upper Eden. The Eden, as used by Doctor Ulrich for a long time, is confined to beds beginning at the top of the true Utica and extending upward to the base of the Maysville. But as originally defined the Eden included all the shales to the top of the underlying Point Pleasant Trenton limestone in the Ohio valley; hence it included also the thinning western representative of the true Utica. For this reason Doctor Ulrich has proposed to use the term Eden for a group comprising the Utica and Frankfort (title 69, plate 27). The Eden in Ohio is followed by the Maysville, which in New York is represented by the Pulaski formation and Oswego sandstone. The Lorraine, we infer from the above-cited chart, is retained as a local or New York term only to comprise the Frankfort and Pulaski formations.

SCHENECTADY FORMATION

As the black shale belt that follows the Mohawk river from Utica to near its mouth has always been considered as being of Utica age, but has been found to change in age from Utica to lower Trenton in descending the river, thus the parallel and coextensive belt of overlying, more argillaceous, olive gray shales has been quite naturally identified with the Frankfort shale by all authors, the present included, since these beds apparently form a continuous belt, just as the underlying black shale does. When we discovered in the great thickness of "Frankfort" beds in Schenectady and Schoharie counties the eurypterid fauna associated with a considerable number (see page 42) of graptolites, brachiopods, mollusks and trilobites, different from those of the Frankfort shale, we distinguished there several thousand feet of sandstones and shales as the "Schenectady facies" of the Frankfort formation. Closer investigation of the faunas, with the assistance of Doctor

Ulrich, has led to the conclusion that they are at least as old as upper Trenton and probably belong mainly between the middle and upper Trenton. We therefore propose to distinguish this formation as a separate unit under the term *Schenectady formation,* its type exposures being at the Dettbarn quarries at Schenectady and at Aqueduct and Rexford Flats near Schenectady.

The conclusion of an age older than the Utica for the Schenectady formation is supported by, or at once explains, the close connection by transitional beds of the Canajoharie beds (which are of lower to middle Trenton age) and these "Frankfort" beds of the lower Mohawk valley, as shown in the section about Minaville and along the Schoharie creek.

The Utica shale, if it continued down the Mohawk valley, would have to be found above the Schenectady beds. This inference is supported by the fact that the latter are overlain by the Indian Ladder shales (see page 50) which correspond in age to the Southgate of the Eden group and are but little younger than the true Utica.

If one follows the foot of the Helderberg escarpment from the typical exposures of the Frankfort shale down the Mohawk valley, one meets but few rather widely separated outcrops of the barren, olive gray Frankfort shales until one reaches the lower Mohawk valley region, where the rather abrupt widening of the belt and the thickening of the formation together with the appearance of much calcareous sandstone (bluestone) combine to change greatly the aspect of the "Frankfort" beds. The exact contact plane between the Frankfort shales that thin out eastward and the Schenectady beds that rapidly diminish westward, has not yet been established and may be entirely buried in the deep drift plateau between the foot of the Helderbergs and the Utica and Canajoharie exposures in the lower reaches of the southern affluents of the Mohawk.

The *thickness* of the Schenectady formation must be very great. Cumings (title 44, page 466) has already found in the hill back of Rotterdam a thickness of 1200 feet at least for the "Hudson River" beds, for the top of the formation is not there reached. That the thickness of the Schenectady formation is still considerably more, is proven by the Altamont well-boring. In that well, the drill started 595 feet below the top of the Indian Ladder beds and passed through 2880 feet of sandstone and shales before reaching the Trenton limestone. The shale formations have hence a total thickness of 3475 feet there. The lowest 1200 feet of this may be

Figure 2 Schenectady beds at Aqueduct, showing the alternating beds of sandstone ("bluestone") and shale

Figure 3 Nearer view of same quarry face to show irregular deposition of beds

attributed to the Canajoharie shale, since Cumings (op. cit. page 466) measured 950 to 1260 feet of black shales in the lower Mohawk region and 300 feet at least at the top belong to the Indian Ladder beds, a formation that follows the Schenectady beds in this region and will be discussed later (see page 50). There remain then 1800–2000 feet of Schenectady beds, since we properly assume that neither the Normanskill nor the Snake Hill beds reach as far west as Altamont. The Normanskill and Snake Hill beds extend considerably farther west than their original basin of deposition (see diagram, page 69) through extensive overthrusting which, however, has not reached the meridian of Altamont where the beds are undisturbed.

There are other lines of evidence which indicate a similar great thickness for the Schenectady shale and sandstone. One of these is the width of the belt of shales from Amsterdam to the Helderbergs which at the rate of 140 feet dip in a mile, observed for the Glens Falls limestone, corresponds to a thickness of 1925 feet of shale (13.75 miles by 140), to which must be added 900 feet representing the difference in height of the base of the shales at the north and their top in the south, subtracting from this 2825 feet again the 1140 feet found in that meridian for the Canajoharie shale, we obtain approximately 1700 feet for the Schenectady beds, the Indian Ladder beds having disappeared along the Schoharie creek section. The dips along the line Aqueduct to Schoharie, which are mostly southwest to west and amount to 1°–2°, frequently as much as 5°, as at Aqueduct, would also indicate a thickness of more than 2000 feet (2681 feet at 1° dip).

The cause of the astonishing thickness of the Schenectady shales is to be sought in their deposition in a basin, namely, the sinking foreland in front of the rising Green Mountain folds to the east; which basin was rapidly being filled with sediments. The shallow water origin of most of the shales and sandstones of the Schenectady beds is proven by the sun-cracks found in the thinner sandstones (as at the Bozen kill), the frequent layers of mud pebble beds,[1] cross striation with plunge structure, very rapid change of thickness of beds and other features.

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[1] These mud pebble layers occur mostly on top of the sandstone beds, when the latter are followed by argillaceous shales, indicating that the first clay deposits were rolled about by the waves upon the sand and formed into mud balls.

The rocks of the Schenectady formation contain a much greater amount of sandstone beds than the other shale formations of New York. Much of this sandstone occurs in thick banks, is somewhat calcareous and much quarried as "bluestone." The hundredfold alternation of these sandstone beds with the shales which persists to a more or less extent throughout the whole formation is the most notable lithic character of the eastern development. Numerous sections which show these endless alternations of sandstone which, on account of its often coarse nature, is cited as grit, with slate, have already been published by Mather in the First District Report (pages 375–79), from the lower Mohawk and from Schoharie county. We insert here as example a section which we have measured in the abandoned quarries and the river bank at Aqueduct and Rexford near Schenectady, in descending order:

1	Argillaceous shale	12′ =	12′
2	Grit banks, about 1 foot thick with shale intercalations ½ foot thick	9′ =	21′
3	Shale, argillaceous	14″ =	22′ 2″
4	Grit	3′ 6″ =	25′ 8″
5	Dark argillaceous shale	13′ =	38′ 8″
6	Grit	6″ =	39′ 2″
7	Shale	2′ =	41′ 2″
8	Compact grit	6′ =	47′ 2″
9	Shale	2′ =	49′ 2″
10	Calcareous grit ("bluestone")	2′ =	51′ 2″
11	Dark argillaceous shale	8′ =	59′ 2″
12	Grit bed	6″ =	59′ 8″
13	Dark shale, separated by fault from underlying beds	3′ =	62′ 8″
14	Grit	6″ =	63′ 2″
15	Shale, dark, argillaceous	2′ =	65′ 2″
16	Thin bedded grit	1′ 6″ =	66′ 8″
17	Bluestone	5′ =	71′ 8″
18	Shale	2′ =	73′ 8″
19	Bluestone	1′ 6″ =	75′ 2″
20	Thin alternating beds of grit and shale, banded and wavy	2′ =	77′ 2″
21	Compact beds of bluestone, with a few thin discontinuous shale seams. Beds irregular	9′ 6″ =	86′ 8″
22	Shale	4′ 6″ =	91′ 2″
23	Grit band with distinct plunge structure	6″ =	91′ 8″
24	Shale, dark, argillaceous	2′ 6″ =	94′ 2″
25	Grit bed with one shale seam	3′ 6″ =	97′ 8″
26	Shale, soft dark gray to black argillaceous and sandy shales	90′ + =	187′ 8″

The constant alternation of more or less coarse sandstone with shales is indicative of a frequent shifting of the conditions, presumably through currents, either reversal (tidal) or continuous currents. There is sometimes clear evidence of absolutely regular or rhythmic shifting. Such a place was for instance observed in an abandoned quarry on the Bozen kill between Altamont and Delanson. The base is here formed by a compact bed of sandstone some 15 feet thick. This sandstone is abruptly followed by dark argillaceous shale in which higher up thin sandstone layers appear, that become more frequent until another thick sandstone bed is formed, like the basal one. This in turn is cut off by a shale, that gradually yields to sand. The whole cycle is in this place repeated three times, shales and sandstones being each of equal thickness, the whole indicating a most remarkable regularity of change of deposition which on account of the very shallow water character of the rocks of that locality, may well have been a condition due to reversal or tide currents.

It agrees well with the evidence of the shallow water or shore origin of the Schenectady shales and sandstones, that they are often densely filled with remains of seaweeds (Sphenophycus latifolius Hall).

In contrast to the Frankfort shales the Schenectady beds have furnished a large fauna, although they had hitherto currently been held to be quite barren. Altogether about 70 species have been found and there appears to be no striking difference in the lower and upper faunas of this great mass of rocks, aside from that of the Indian Ladder beds, which have been separated as a distinct formation.

The following are the faunal lists from the principal localities.

The easternmost outcrops which represent very low beds of the formation are those at *Aqueduct* and *Rexford Flats,* three miles northeast of Schenectady; these have afforded the following association of species:

Sphenophycus latifolius (*Hall*)	(cc)
Azygograptus *sp. nov.*	(r)
Mastigograptus *cf.* simplex *Walcott* (fragment)	(rr)
Climacograptus typicalis *Hall*	(c)
Diplograptus vespertinus *Rued.*	(c)
Lingula rectilateralis *Emmons*	(rr)
Leptobolus insignis *Hall*	(c)
Rafinesquina alternata (*Conrad*) (small)	(c)
Serpulites	(rr)

Cyrtolites *sp.* (very young example)	(rr)
Trocholites ammonius *Conrad*	(r)
Cyrtoceras *sp. nov.*	(r)
Spyroceras bilineatum (*Hall*)	(rr)
Triarthrus becki (*Green*)	(r)
Isotelus *cf.* gigas *Dekay*[1]	(rr)
Primitia (minute form)	(cc)
Eurychilina	(r)
Pterygotus prolificus *Clarke & Ruedemann*	
P. nasutus *Clarke & Ruedemann*	

A much larger collection was obtained two miles farther southwest in the bluestone quarries at the northeastern outskirts of Schenectady, notably the Dettbarn quarry. This has afforded:

Sphenophycus (*Hall*)	(cc)
Mastigograptus *sp. nov.*	(r)
Climacograptus typicalis *Hall*	(cc)
Lasiograptus eucharis (*Hall*)	(c)
Crinoid joints	
Leptobolus insignis *Hall*	(c)
Lingula rectilateralis *Emmons*	(r)
Dalmanella testudinaria (*Dalm.*) (small)	(c)
Conularia trentonensis *Hall var.* multicosta *nov.*	(r)
Modiolopsis *cf.* modiolaris (*Conrad*)	(c)
Saffordia ulrichi *nov.*	(rr)
Cyrtoceras *sp. nov.*	(c)
Spyroceras *cf.* bilineatum (*Hall*)	(r)
Trocholites ammonius *Conrad* (small)	(r)
Triarthrus becki *Green*	(c)
Trinucleus concentricus *Eaton*	(rr)
Eurypterus pristinus *C. & R.*	(r)
E ? (Dolichopterus) stellatus *C. & R.*	(r)
Eusarcus triangulatus *C. & R.*	(c)
E ? longiceps *C. & R.*	(r)
Dolichopterus frankfortensis *C. & R.*	(r)
D. latifrons *C. & R.*	(r)
Hughmilleria magna *C. & R.*	(cc)
Pterygotus ? nasutus *C. & R.*	(r)
P. prolificus *C. & R.*	(c)
Stylonurus ? limbatus *C. & R.*	(c)

The next series of outcrops which, on account of the southwest dip of the beds, are probably a little higher in the Schenectady formation, are those at Rotterdam Junction. Prosser and Cumings have described (title 33, page 658) a small section nine-tenths of a

[1] This is a large complete individual 6.5 inches long, from the "bluestone."

mile west of the Schenectady pump station, from a deep glen and a long cut on the West Shore Railroad. This section is as follows:

		Feet
I C 1	Covered from level of Mohawk river to Erie canal.....	25 = 25
C 2	Fine shale which at the base of the glen does not weather readily to soil. Graptolites are fairly abundant	110 = 135
C 3	Very fragile shale exposed in the railroad cut	12 = 147
C 4	Thin sandstone layer	2/12 =
C 5	Shale	1 5/12 = 148 7/12
C 6	Thin layer of sandstone.....	
C 7	Crumbling arenaceous shale	3 5/12 = 152
C 8	Heavy layer of sandstone by the highway which runs under the railroad track east of the cut...	2 = 154

The following fossils are recorded "from a very thin layer of loose-grained, arenaceous shale exposed near the base of the railroad cut on both sides of the track and largely composed of the comminuted fragments of fossils":

1 Triarthrus becki *Green* (c)
Numerous small fragments of the pleurae and a few complete specimens of the glabella
2 Trinucleus concentricus *Eaton* (c)
Mostly fragments of the spines and cheeks
3 Plectambonites sericeus (*Sowb.*) *H. & C.* (?) (c)
All the specimens are very small and rather coarsely striated.
4 Dalmanella testudinaria (*Dalm.*) (r)
5 Orbiculoidea *sp.*
6 Monticulipora (Prasopora) lycoperdon *Say* (?) (r)
7 Crinoid segments (r)
8 Graptolites

Cumings (title 44, page 45,) has later described a fine section exposed in a ravine on the northeastern slope of Waterstreet hill. This is as follows:

2 I Rotterdam section

I[1]	Near the railroad arch in the bottom of the creek 8 feet of very thin, fragile, dark grayish to bluish black, argillaceous shales with occasional very thin sandy layers, one near the middle of the stratum being about 1 inch thick.....	8′ = 8′

I^{2}	Heavy, compact sandstone of grayish to greenish blue color, weathering gray to brown.....	10′ = 18′
I^{3}	Mainly grayish, friable shales with thin layers of sandstone	12′ = 30′
I^{4}	Heavy sandstone with intercalated shale.....	6′ = 36′
I^{5}	Dark crumbling shale.....	8′ = 44′
I^{6}	Shale with mainly thin, but some heavy layers of sandstone	37′ = 81′
I^{7}	Heavy stratum of sandstone.....	4′ = 85′
I^{8}	Shales with some thin layers of sandstone.....	15′ = 100′
I^{9}	Thick to thin and broken layers of sandstone....	10′ = 110′
I^{10}	Fine shale	5′ = 115′
I^{11}	Thin broken sandstone with crumbling shale.....	45′ = 160′
I^{12}	Shale	5′ = 165′
I^{13}	Thin sandstone and shale. Base of high waterfall.	5′ = 170′
I^{14}	Thin friable blackish shale by excavation of which from beneath the sandstone above, the fall has been formed	12′ = 182′
I^{15}	Two layers of massive sandstone over which the water falls	8′ = 190′
I^{16}	Thin sandstone layers.....	2′ = 192′
I^{17}	Clear dark shale.....	4′ = 196′
I^{18}	Apparently heavy-bedded sandstone weathering to thin often lenticular divisions.....	25′ = 221′
I^{19}	Shales and thin sandstones.....	10′ = 231′
I^{20}	Medium thick layers of sandstone with massive 2 foot layer at base and some thin beds of shale, and shaly partings.....	39′ = 270′
I^{21}	Mostly covered. Highly inclined layers of sandstone exposed in the creek banks 120 feet above No. 20	120′ = 390′
I^{22}	Covered to top of hill but with an occasional exposure of sandstone. 680 feet by barometer..	680′ = 1070′

We have carefully collected in this splendid section and found the following fossils:

In I^{3}	Climacograptus spiniferus *Ruedemann*	(c)
	Eurypterid fragments	
In I^{6}	Climacograptus spiniferus *Ruedemann*	(c)
	Leptobolus insignis *Hall*	(r)
	Eurypterid fragments	
In I^{11}	Sphenophycus latifolius (*Hall*)	(c)
In I^{13}	Eurypterid fragments	
In I^{15}	Sphenophycus latifolius (*Hall*)	
In I^{20}	Sphenophycus latifolus (*Hall*)	(cc)
	Callograptus multiramosus *nov.*	(rr)
	Rhytimya *sp.*	(rr)
	Eurypterus megalops *Clarke & Ruedemann*	(rr)

Eusarcus triangulatus *C. & R.*	(r)
Dolichopterus frankfortensis *C. & R.*	(c)
Hughmilleria magna *C. & R.*	(c)
Pterygotus prolificus *C. & R.*	(c)

In following the dip of the rocks, a long series of outcrops were found beginning at Duanesburg, about ten miles west-southwest from Schenectady, and extending about four miles along the railroad to Delanson. The dip is too small to measure accurately, different measurements giving from 1° to 2°, but it is safe to assume that these outcrops which are halfway between the lower beds at Schenectady and the top of the formation at the Helderbergs are 1000 feet above the base.

In a bluestone quarry just above the station at Duanesburg about 40 feet of thicker and thinner, partly coarser sandstone beds with intercalated gray, argillaceous and often also arenaceous shales are exposed. The sandstone beds are distinctly lenticular, rapidly thinning out and swelling up in the quarry face and carrying numerous mud pebbles near their surfaces. The shaly layers show fine cases of mud-flow and the whole character of the beds indicates a rather shallow, current or wave-swept sea. The shale seams are profusely filled with seaweeds and fragments of eurypterids.

The following species were obtained:

Sphenophycus latifolius (*Hall*)	(cc)
Climacograptus bicornis *Hall*	(r)
Camarotoechia *sp. fragments*	
Dolichopterus frankfortensis *Clarke & Rued.*	(c)
Eusarcus triangulatus *C. & R.*	(c)
Stylonurus ? limbatus *C. & R.*	(r)
Hughmilleria magna *C. & R.*	(c)
Pterygotus prolificus *C. & R.*	(c)
P. ? nasutus *C. & R.*	(r).

The beds can be followed along the Schenectady branch of the Delaware & Hudson Railroad in a continuous exposure to Delanson, without any change in lithic or faunal character. Following then the southwest dip no outcrops are met with until the Schoharie valley is reached, where a number of small exposures are observed in the river bank above Schoharie Junction. These represent the uppermost portion of the Schenectady beds and can not be more than 300 feet below the top, or the boundary with the Brayman shales in the hills to the east and west of the valley. The beds are still the same alternating thick impure sandstones and dark gray to

black shales. It is, however, obvious that the sandstones have become more silicious and are prevailingly gritty, often coarse and assuming the character of an arkose, as notably at Duanesburg. The top layer of the sandstones frequently contains numerous mud pebbles inclosed in the sandstone.

The following fossils were collected along Schoharie creek:

Sphenophycus latifolius (*Hall*[1])	(r)
Climacograptus typicalis *Hall*	(c)
Taeniaster schohariae *nov.*	(rr)
Conularia trentonensis *Hall var.* multicosta *nov.*	(rr)
Eurypterida: Dolichopterus frankfortensis; Pterygotus *sp.*	

While in the Schoharie valley the Schenectady beds can not be followed to their contact with the overlying Brayman shales, this can be done along a small northern branch of the Cobleskill between Central Bridge and Howes Cave, which has been pointed out by Grabau (title 56, page 102) as an excellent exposure of the Brayman shales. Here about 120 feet of Schenectady shales and sandstones are exposed in the ravine above and below the road. The lower portion consists prevailingly of dark gray to brownish green, sandy shales with black argillaceous shales in thinner seams. These change upward into purely sandy shales, which grade into a sandstone about 20 feet thick that is followed by the Brayman shale. The lower shales furnished great quantities of Sphenophycus latifolius and many fragments of eurypterids, among these chelicerae of Pterygotus, and carapaces of Pterygotus prolificus, Eurypterus pristinus, Dolichopterus cf. frankfortensis and Hughmilleria cf. magna. These eurypterid remains could be traced into the bottom of the topmost sandstone bed. Thus we see that here the eurypterid fauna indicative of the Schenectady formation reaches close to the Brayman shales which are supposed to be of Upper Siluric age (see postea page 54).

Another series of outcrops of the middle and lower Schenectady formation is found along the Schoharie creek from Central Bridge

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[1] This is the type locality of the species. Hall states of the occurrence of the latter: "This species occurs in considerable abundance near Schoharie, in the bed of the creek, in the central part of the Hudson River group. I have not seen it in any other locality." We have not been able to find Gebhard's old locality at Schoharie, but as is seen from the lists, have observed this remarkable seaweed in sometimes immense quantities in other outcrops, as at Kellum's quarry near Schenectady and in the Rotterdam Junction section.

to Fort Hunter, at the mouth of the creek. About seven and one-half miles south of Fort Hunter the contact of the Canajoharie shale with the Schenectady is a very distinct one. The section at this contact in a cliff on the western side of the creek, three miles south of Mill Point, has been described by Prosser (1900, page 470), as follows:

		Feet
45X[1]	Clear black shale from the water to the base of lowest sandstone stratum in the cliff, 114′ by level and 105′ by barometer. At the sandstone stratum there is a decided lithologic break from the black argillaceous shales below. Utica shale.....	114 = 114
X[2]	Grayish sandstones alternating with bluish argillaceous shales to the top of the cliff. Hudson River formation.....	195 = 309
X[3]	Mostly covered from the top of the cliff to the highway	15 = 324
X[4]	Occasional ledges of sandstone show on the side of the hill from the highway nearly to its top. Hudson River formation.....	120 = 444

From this point up the river a splendid series of exposures of the Schenectady formation is furnished by the river banks. The section from Burtonville (formerly Burton's bridge) to Esperance has already been described in detail by Mather (title 2, page 379). Hundreds of feet of rock are here exposed in magnificent cliffs; on investigation they prove, however, a monotonous alternation of sandstone or grit beds with shales with an extreme scarcity of fossils. As far as fossils were observed (a few traces of Climacogr. typicalis in the upper layers and Sphenophycus latifolius in the lower shales), they show the great uniformity of the fossil content throughout the entire series of beds here comprised as Schenectady shale.

A third group of fossiliferous outcrops has been observed by us five to ten miles south of Schenectady, directly in front of the Helderbergs, along the Normanskill and its branches, the Bozen kill and the Vly near the villages of Altamont, Guilderland and Voorheesville. We have already described on page 41 the remarkable alternation of sandstones and shales at the Bozen kill. Continuous outcrops ranging through 200 and 300 feet of rock are found in the upper branches of this kill west of Altamont, which form deep ravines in the lower slope of the Helderberg escarpment. These beds consist prevailingly of bluish and greenish gray shales with several intercalations of sandstone beds, the latter reaching

15 feet in thickness. The beds are nearly barren; only a few fragments of eurypterids were found in the lowest portion. More fossiliferous proved the excellent exposures along the Vly beginning at the fall a mile below Voorheesville. These beds are from 500–600 feet or more from the base of the Upper Siluric beds (Manlius waterlime) of the Helderbergs. The beds of that section are at the western edge of the Appalachian folds of the slate belt of New York and still slightly disturbed by small folds and some overthrusts of probably small throw. The upper beds of this section, which comprises about 200 feet, consist of fossiliferous black to grayish argillaceous shales with several sandstone intercalations and the lower beds of black shales with but few and thin sandstone beds. These shales, of which 80 feet are exposed in the steep eastern bluff of the creek, were formerly referred by the writer (title 47, page 532) on account of their lithic character and fossil contents to the Utica shale. We have now a much larger fauna from this section at our disposal which, with our present knowledge of the shale faunas, throws a different light upon the question of the age of these shales. The latter contain:

Diplograptus vespertinus *Rued.*	(c)
Diplograptus (Mesogr.) putillus *Hall*	(cc)
Climacograptus typicalis *Hall*	(c)
Leptobolus insignis *Hall*	(r)
Minute individuals of Rafinesquina	
Pterinea (Prolobella) trentonensis *Conrad*	(r)
Orthoceras *sp. nov.* ("Endoceras proteiforme")	(c)
Lepidocoleus jamesi *H. & W.*	(r)
Primitia *sp.*	

The sandstone layers of the upper portion have furnished:

Climacograptus typicalis *Hall*	(c)
Hughmilleria *cf.* magna *C. & R.*	(r)

An excellent section leads from these beds up to the Upper Siluric along a branch of Black creek at the Indian Ladder. The beds here exposed have furnished a different fauna and are described further on (p. 50) as Indian Ladder beds.

The combined faunal list of the Schenectady formation is:

Sphenophycus latifolius (*Hall*)
Dictyonema multiramosum *nov.*
Azygograptus *sp. nov.*
Mastigograptus *nov. cf.* simplex *Walcott*
M. *sp. nov.*

Figure 4 Bega's cliff on Schoharie creek. Canajoharie shale at base; Schenectady beds above.

Diplograptus vespertinus *Rued.*
Climacograptus bicornis *mut.* ultima *nov.*
C. typicalis *Hall*
Lasiograptus eucharis (*Hall*)
Crinoid joints
Taeniaster schohariae *nov.*
Lingula rectilateralis *Emmons*
Leptobolus insignis *Hall*
Dalmanella testudinaria (*Dalman*)
Rafinesquina ulrichi *James* (typical)
Plectorthis plicatella *Hall*
Orbiculoidea *sp.*
Conularia trentonensis *Hall var.* multicosta *nov.*
Serpulites *sp.*
Saffordia ulrichi *nov.*
Cyrtolites *cf.* ornatus *Conrad*
Cyrtoceras *sp. nov.*
Spyroceras bilineatum (*Hall*)
Trocholites ammonius *Conrad*
Triarthrus becki (*Green*)
Isotelus gigas *Dekay*
Trinucleus concentricus *Eaton*
Primitia
Eurychilina *cf.* subrotunda *Ulrich*
Eurypterus pristinus *Clarke & Ruedemann*[1]
E. megalops *C. & R.*
E ? (Dolichopterus?) stellatus *C. & R.*
Eusarcus triangulatus *C. & R.*
E ? longiceps *C. & R.*
Dolichopterus frankfortensis *C. & R.*
D. latifrons *C. & R.*
Hughmilleria magna *C. & R.*
Pterygotus nasutus *C. & R.*
Stylonurus ? limbatus *C. & R.*

The dominant elements of this large fauna are certain Canajoharie and Utica shale species on one hand, and the eurypterids on the other. The former elements are the species of Mastigograptus, Diplograptus vespertinus, Climacograptus typicalis, Lasiograptus eucharis, Leptobolus insignis, Trocholites ammonius[2]

[1] The eurypterids are described and figured in the forthcoming Memoir on the Eurypterida of New York by Clarke and Ruedemann.

[2] Trocholites ammonius Hall is a form that probably occurs entirely or mainly below the Utica in the Canajoharie shale. Its type localities (title 3, p. 309) are the East Canada creek, Canajoharie and Coldspring, all three localities of shales older than the Utica.

and Triarthrus becki. These are also the most frequent species, and the entire fauna receives thereby a distinct Canajoharie-Utica aspect. But we also note in the congeries of forms a number of species that are not observed in either the Canajoharie or the Utica, but are known only from the Trenton. Such species are Lingula rectilateralis, Conularia trentonensis, Spyroceras bilineatum, Trinucleus concentricus, Eurychilina. It is mainly the evidence from these fossils that indicates the Trenton age of the Schenectady formation. Finally there is a strong element of entirely new species, giving the Schenectady beds a distinct character of its own; this element consists of a few rare species, as Dictyonema multiramosum, Taeniaster schohariae, Saffordia ulrichi, and especially of the eurypterids. It is true the Echinognathus clevelandi Walcott, of the Utica shale of Holland Patent, N. Y., may be contained in this Schenectady fauna, and thus also one eurypterid at least be a Utica element, but there is still no doubt that the eurypterids of the Schenectady beds constitute a strong distinctive feature from the Utica fauna as known to us at present.

If we attempt to compare this formation with others outside the State, we find similar shale beds of upper Trenton age in the lower third of the Martinsburg shale (title 62, page 62) in Pennsylvania, extending thence probably into the Martinsburg shale of New Jersey and south into Maryland.

INDIAN LADDER BEDS

The best section known to us leading from the Schenectady beds up to the Upper Siluric beds, is along the upper left branch of Black creek forming the fall and deep ravine at the Indian Ladder near Meadowdale, Albany county, N. Y. The section comprises about 410 feet (aneroid measurement), of which the lowest 100 feet are dark gray to black argillaceous shales with two thick sandstone bands (each about 4 feet), while the next 100 feet are of a character not met with in other outcrops of the Schenectady beds. They consist of rapidly alternating dark gray shales and thin rusty looking, somewhat calcareous sandstone layers, ½ to 1 inch or more thick. The uppermost part of this portion becomes quite sandy. Nearly 100 feet are there covered, while some 120 feet at the top consist of prevailingly heavy sandstone beds with intercalated dark arenaceous and argillaceous shales, and an occasional

thin limestone band. The top is formed by a white hard sandstone bank 3½ feet thick and consisting largely of rounded sand grains. This is separated by shale, one layer of which consists of pyrite, from an underlying gray sandstone bed, also composed of rounded grains. The sandstone beds of this upper part of the formation are extremely irregular courses; in one case a bed was seen to run out within 10 feet from 4 feet to ½ foot.

These beds present an extremely barren aspect; the only observation of fossils in them of which we are aware is that by Walcott (title 17, page 345) who states: "The only fossils I found at this locality were Orthis testudinaria and Trinucleus concentricus." Very thorough search has furnished us a small graptolite faunule in the shales of the lower 200 feet and another faunule in the thin calcareous sandstone intercalations of the second hundred feet. A few bands of the latter proved to be covered with the remains of a microfauna, especially small crinoid joints.

The shale has furnished:

Dictyonema arbuscula *Ulrich*	(r)
Diplograptus peosta *Hall*	(r)
Dicranograptus nicholsoni *Hopkinson* (typical)	(rr)

The sandstone contains a pronounced microfauna which has been kindly determined for us by Doctor Ulrich as follows:

1	Columns and calyx plates of a cystid allied to Cheirocrinus	(r)
2	Very pentagonal columns	
3	Small Heterocrinus columns	(cc)
4	Callopora nealli (*James*) *Ulrich*	
5	Arthrostylus tenuis *Ulrich*	
6	Helopora *n. sp.*	
7	Rhinidictya *cf.* parallela (*James*)	
8	Rafinesquina ulrichi (*James*)	(cc)
9	Plectambonites *nov.* (= centricarinatus *nov.*)	(c)
10	P. plicatellus (*Ulrich*)	
11	Dalmanella multisecta (*Meek*)	(c)
12	Lepidocoleus jamesi (*Hall & Whitfield*)	(c)
13	Ceratopsis chambersi (*Miller*) (typical)	(c)
14	Trinucleus bellulus *Ulrich*	(c)
15	Acidaspis crossota *Locke*	(c)
16	Calymmene (Cincinnati Eden species)	

We also had a Tentaculites cf. flexuosa Hall, a small Hyolithes, fragments of Ceraurus pleurexan-

themus Hall and small cranidia of a Dalmanites (Pterygometopus).

Doctor Ulrich has determined the horizon as corresponding to the lower third of the Southgate shale of the Eden group at Cincinnati.

A comparison of the fossil list here given with that of the Schenectady beds shows at once that the "Frankfort" beds of the lower Mohawk valley contain two distinct faunas. The beds at the Indian Ladder also differ in their lithologic aspect; it is therefore safe to distinguish them as a separate unit, for which the name *Indian Ladder* beds is here proposed.

The Indian Ladder fauna is markedly distinct from the Schenectady fauna in the absence of all the dominant forms of the latter, as notably the eurypterids, Climacograptus typicalis, Triarthrus becki, Trocholites ammonius and the seaweeds. It consists on the other hand of a congeries that has hardly any members in common with the Schenectady beds. Much of this is clearly due to a different facies or different marine conditions, at least in the contents of the rusty limestone bands; for instead of the mud-loving linguloids and lamellibranchs of the Schenectady beds, we find here the strophomenoids and orthoids, indicating clearer water. The novel element of this faunule is represented principally by bryozoans, brachiopods, the ostracod Ceratopsis chambersi and the trilobites (Acidapsis crossota, Trinucleus bellulus) and the reappearance of such Trenton forms as Dalmanites callicephalus and Ceraurus pleurexanthemus. Also the graptolite faunule of the shale is totally different from that of the Schenectady beds. In Dicranograptus nicholsoni it contains an upper Trenton and lower Utica element, that here reappears after a long interval, in Diplograptus peosta, the first forerunner of the Lorraine fauna and in Dictyonema arbuscula, a form of the middle Eden shale of Ohio. The combined evidence of the whole fauna is that the Indian Ladder beds are younger than the Schenectady beds, not a mere different facies of the same, but still older than the typical Lorraine.

The horizontal extension of the Indian Ladder beds in the exposures at the base of the Helderberg escarpment seems to be but very restricted. In the section obtained along the roads south of Altamont, only four miles west of the Indian Ladder,

Figure 5 Upper part of type exposure of Indian Ladder beds at the Indian Ladder, showing the alternating shale and thin fossiliferous limestone beds

Figure 6 Lower part of the same exposure, showing the thick-bedded sandstone with shale alternations

Sphenophycus latifolius was observed only 180 feet below the Manlius limestone. Since we have not observed this fossil in the Indian Ladder beds and consider it as characterizing the Schenectady formation, it would follow that the Indian Ladder beds are here already reduced to less than 200 feet in thickness. The orange colored rusty limestone bands of the lower Indian Ladder formation were in this section observed at several places above the Sphenophycus beds.

Westward between Altamont and Schoharie the uppermost part of the Lower Siluric is nearly everywhere found buried under drift. In the road-ditch halfway between East and West Township the characteristic orange colored limestone was observed only 10 feet below a ledge of Manlius limestone.

To the east of the Indian Ladder the only opportunity for the observation of the Indian Ladder beds is afforded by the New Salem sections described by Prosser and Rowe (title 34, page 334). The authors describe there two sections, one the Countryman Hill section, and another south of New Salem. In the former section 57 feet of "bluish gray, fairly massive sandstones which alternate with dark colored argillaceous shales," are cited as representing the Lower Siluric. These are separated by a covered interval of 10 feet from the Manlius limestone. In the other section, which is but half a mile to the east, the contact between the Lower Siluric and the overlying beds is shown. Prosser and Rowe describe the lower part of the sections as follows (op. cit. page 338):

	Feet
B4 Thin bedded dark blue limestone. *Tentaculite limestone*	32 1/2
B3 Drab, impure limestone, well exposed in the run at the foot of the cliff. *Waterlime*	6 1/2
B2 Greenish sandstone to coarse arenaceous shale containing plenty of iron pyrites, 10 inches in thickness. Possibly it represents the attenuated Clinton formation	1/2
B1 Dark blue to olive tinted argillaceous shales well exposed in the steep banks of the brook. *Hudson River shales*	90

A third outcrop of the Lower Siluric shales is found between these two in the culvert and ravine just south of New Salem at the new State road. Here about 20 feet of dark shales with a few sandy layers are exposed, which extend within 15 feet from the Manlius (Tentaculite) limestone.

None of these three localities has furnished the writer any fossils save a few small crinoid joints in the last mentioned; hence the fossil evidence leaves the question of the correlation of these beds open. The absence of the Sphenophycus latifolius, of fragments of eurypterids and Climacograptus typicalis would, however, indicate that these beds belong to the Indian Ladder beds which for the greater part are entirely barren. Lithologically they also lack the orange colored rusty thin limestone bands which characterize the lower portion of the Indian Ladder section. It is, however, quite apparent that the New Salem sections do not reach far enough down into the Indian Ladder beds to expose these fossiliferous bands. The beds of the Countryman Hill section correspond to the upper beds of the Indian Ladder section.

A noteworthy feature of the two sections of the Lower Siluric beds at New Salem is the horizontal change from the prevailing thick sandstone beds of the Countryman Hill section to the dark shales of the other sections in the astonishingly short distance of less than half a mile.

Brayman shales

The status of the Brayman shales has been lucidly brought up to date by Grabau (title 56, page 101). He says:

These with the exception of the basal sandstones, are the only beds of the Salina period occurring in this region. They have been variously described in the literature as Clinton shales, pyritiferous shales, Salina shales, etc. The name Brayman shales is chosen for them from the village of Braymanville on the Cobleskill, between which place and Howes Cave they are well exposed. As the shales have so far proved unfossiliferous their exact equivalency is somewhat uncertain. From their position immediately below the Cobleskill limestone it may be confidently inferred that they are of Salina age, but whether they represent the Bertie waterlime of Buffalo, which is the immediate predecessor of the Cobleskill of that region, or whether they are of somewhat earlier age is a question difficult to determine. That there is a slight hiatus between the Brayman shales and the Cobleskill seems to be indicated by the fact that the upper bed of these shales is somewhat conglomeratic, with rounded or elongate pebbles of clay shale inclosed in a dark matrix, partly a calcareous sand and containing numerous scattered, rounded quartz grains. This indication of wave activity at the end of deposition of the Brayman shales and the want of transitional beds between the clay shale and the lime sandrock (Cobleskill) suggest that there is a short time interval unrepresented. This fact, together with the

distinctive character and local development of these shales, demands their description under a separate name, as a local member of the Salina series of deposits, whose exact equivalent in the complete Salina series of Central New York is doubtful.

The main mass of the Brayman shale is an olive or grayish clay rock often alternating with bluish beds and weathering to a lighter color, and having the appearance of a solid mudbank. Concretions of iron pyrites are very abundant and of all sizes, though generally not much larger than a man's fist. The pyrite is commonly an aggregate of crystals, often of considerable size, the cube and pyritohedron being about equally represented. Exposed portions rapidly oxidize changing to an ochery color, and commonly stain the adjoining shales. As already noted, no fossils have yet been found in this formation.

Near Mix and O'Reilly's quarry northeast of Schoharie, Hartnagel's measurement showed 27 feet of these shales. This gives a decrease of 13 feet in a distance of 5 miles. At this point, near the crusher, the contact with the underlying sandstone is well exposed, the two series of strata being absolutely conformable. The surface of the sandstone, exposed for several hundred yards, appears to be a perfectly normal deposition surface, and no trace of erosion, such as we might expect if there was an interval covering Lower and Middle Siluric time, is visible. Moreover the sandstone is pyritiferous like the shale, and no fragments of the lower rock are found in the Brayman shales. Neither does the surface of the top sandstone layer show traces of weathering before the deposition of the Brayman shales.

It is inconceivable that the surface of this sandstone even if worn down to a uniform stratum, should be swept absolutely clean before the shales were deposited, so that no fragments of sandstone are found in the shale. It is clear that all the facts point to the intimate relationship between the upper beds of sandstone and the Brayman shales, making these sandstones of Upper Siluric (Salina) age. The unconformable contact between these sandstones and the Champlainic beds (Lorraine) must be looked for some distance down in the sandstone series.

The most easterly extension of the Brayman shales, so far as has been observed, is according to Hartnagel . . . near Gallupville, 5 miles east of Schoharie, showing that the extreme eastern extension of the great Salina beds of New York can not be far from the town of Knox, Albany county, at which place it is quite likely that the Cobleskill slightly overlaps the Salina. Both of these formations are absent at Altamont, a few miles farther east, and the Rondout is seen resting directly on the Lorraine beds.

The age of the shales here considered has been variously judged. The name pyritous or pyritiferous shales was applied to this formation by the early geologists, and since it occurred below the Coralline or Cobleskill limestone, which was regarded as of Niagara age, and above the Shawangunk grit, which was supposed to be the

equivalent of the Oneida conglomerate of central New York, its age was assumed to be Clinton. Recent investigations by Ulrich and Schuchert,[1] and by Hartnagel, have shown that the formation in question is of late Siluric age, the former authors regarding it as a part of the Cobleskill and including it within the Manlius series, while Hartnagel, Clarke and others regard it of Salina age. As will be shown presently, it is probably the partial equivalent of the lower cement bed of Rosendale which in turn represents a part, but probably not a whole, of the Bertie waterlime series of western New York.

It is seen from this discussion that the Brayman shales rapidly disappear eastward and that they have been correlated with the Salina on account of their position below the Cobleskill limestone. Grabau has argued that the Brayman is more closely united with the underlying sandstone of the "Lorraine" beds than with the overlying Cobleskill limestone. For that reason, he would transfer these sandstones into the Upper Siluric (Salina) age,[2] expecting to find the unconformable contact with the "Lorraine" beds below them. We have, however, pointed out in the description of the Central Bridge section, that the eurypterids of the Schenectady shale continue into the lower part of this sandstone, and that the sandstone beds of the top of the Schenectady shale in that section are also united with the Brayman shale by their pyrite nodules, exactly as in Mix and O'Reilly's quarry at Schoharie (Grabau, page 103). One would, from this evidence, rather infer that the top sandstone of the "Lorraine" (Schenectady) shale, by its close relationship to the Brayman shale, draws the latter into the Lower Siluric. No fossils have been found in the Brayman shale and the formation has not been directly traced eastward or westward into another formation, thereby revealing its true age by direct evidence.

We have therefore in the correlation of these shales to rely for the present entirely on indirect evidence.

In the attempt to trace the shale eastward along the foot of the Helderberg escarpment outcrops fail outside the Schoharie recess in the escarpment until the Indian Ladder and the New Salem sections are reached, where 10 inches of "greenish sandstone to coarse

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[1] Ulrich and Schuchert, in their "Seas and Barriers," accepted merely previous determinations. R.

[2] Grabau follows here merely the general though unfounded assumption of the Salina age of the Brayman shale. Assuming that the sandstone is of Ordovicic age, the same line of arguments would show the Brayman shale to be of Ordovicic and not of Salina age.

arenaceous shale containing plenty of iron pyrite" is found between the top of the Indian Ladder beds and the waterlime. This bed corresponds in its lithic character and aspect, position and especially also in the strong pyrite content so much to the Brayman shale, that it is a fair inference to consider it as the last eastern trace of the formation.[1] It is here as sharply separated from the overlying waterlime (Rondout waterlime), as it is from the Cobleskill beds at Schoharie and it is likewise sharply separated from the underlying Indian Ladder beds.

Extending so far east beyond the Cobleskill limestone, it is non-contiguous with the latter and independent from it; but it is also to be noted that the bed overlies both the Schenectady shale (at Schoharie) and the Indian Ladder beds at the Indian Ladder, which would seem to make it independent from the Schenectady shale.

Westward from the typical outcrops of the Brayman shale in the Helderberg recesses of the Schoharie creek and Cobleskill, we are not aware of any other outcrops but that at Sharon Springs exposing the contact of the "Frankfort" shale with the overlying beds. At Sharon Springs, both Mr Hartnagel and the writer have noted that the basal beds of the waterlime (corresponding to either the Bertie waterlime or the Camillus) are largely composed of greenish, olive and bluish clay shale resembling the Brayman shale, but lacking the pyrites, and apparently passing by gradation into the typical waterlime. The inference would be that in this locality, which is 10 miles northeast of the Central Bridge outcrop, where the Brayman shale is 27 feet thick, the Brayman shale is merged into the lower Salina beds and this is probably the most potent argument that can be brought forward for a correlation of the Brayman shale with the Salina beds, especially since the thickness of the waterlime at Sharon Springs (about 30 feet) roughly corresponds to that of the Brayman shale at Brayman and Central Bridge.

But the absence of the pyrite in the basal waterlime at Sharon Springs and the restriction of the bluish shales to the base would suggest that we here have possibly reworked Brayman shales before us.

Mr Hartnagel has observed that most formations overlying the Frankfort shales are charged with the iron pyrite at their base, as

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[1] Harris (Bull. Am. Pal. no. 19, p. 25) has indeed compared the bed with the Brayman shale, while Grabau (title, p. 292) considers it as the "basal clastic beds of the Rondout."

the Oneida conglomerate in the Frankfort section. It then is probable that the Frankfort shale is the source of this pyrite and that the pyritiferous layer capping the Frankfort, Schenectady and Indian Ladder beds is a residual clay representing the long hiatus that corresponds to the remainder of the Ordovicic and the greater part of the Siluric. The thickness of the Brayman shale, its lithic character and overlapping distribution argue in favor of its residual origin. In that case the presence of the pyrite in both the Brayman shale and the top sandstone of the Schenectady shale would lose its force as a connective of the two formations and the exact age determination of the shale again becomes impossible from that criterion.

But the facts remain that the Brayman shale, where it is thickest and typically exposed, rests upon Schenectady beds, or beds as old as the upper Trenton age and that there is apparently, as pointed out by Grabau, no erosion interval observable between the top sandstone of these Schenectady beds and the Brayman shale; and the conclusion is hence permissible that the Brayman shale should be correlated with some part of the Upper Ordovicic (i. e., the Cincinnatian) rather than the Salina. My correspondence has shown that Doctor Ulrich and the author had reached the same conclusion independently at their separate visits to the Schoharie region, and Doctor Ulrich has in the Revision of the Paleozoic Systems correlated the Brayman shale with the Frankfort (title 69, plate 27).

Snake Hill beds

The separation of the Canajoharie beds from the Utica formation necessitates the recognition and definition of a further unit in the slate belt of the upper Hudson River region. A large fauna had been collected from these beds by the author about the mouth of the Mohawk river and published in 1901 in New York State Museum Bulletin 42. The principal localities were the east and north shores of Green island, Van Schaick island, Block island, Mechanicville, and Brothers' quarry at Troy. On the strength of these faunules the shales had been referred to the lower and middle Trenton (Watervliet, Port Schuyler), Utica and Lorraine. In Memoir 11, page 29, this belt of shale has, on the evidence from the graptolites, been correlated with the upper Trenton and the name Magog shale from the graptolite locality Magog in Quebec applied to it. Investigations since carried on in this slate belt about Saratoga lake have furnished a large addition to the fauna hitherto

known; and by the relations of the beds to the Canajoharie shale and the new fossils discovered the inference of the Trenton age of these shales has been much strengthened.

While we have little doubt of the approximate equivalency of the Magog shale with this shale of the Hudson valley, the fact that the former contains only a graptolite fauna, while the shale in the Hudson valley carries a mollusk fauna and that but few graptolites are common to the shale in Quebec and that on the Hudson, suggests that in the present state of our knowledge, at least, it is more appropriate to distinguish the two terranes by different names, especially also since we do not know whether the two are continuous and deposits of the same basin. Our reason for identifying the two shales was the occurrence in both of certain graptolites, notably Climacograptus caudatus, C. scharenbergi, Cryptograptus tricornis and species of Corynoides. All these are, however, European species which very well might have entered the different channels in the Appalachian system of troughs from the Atlantic basin to the east, as for instance through the St Lawrence region and the New Jersey inlet.

On account of the large faunas obtained on Snake hill on the east shore of Saratoga lake we will designate these shales as *Snake Hill shales*. Their lithologic character and their section on the east shore of Saratoga lake will be fully described in the Schuylerville quadrangle to be published together with the Saratoga quadrangle by Professor H. P. Cushing and the writer.

A large list of fossils were recorded from this formation in a former publication (title 47), but this original list needs revision, since a great many of the species had been only compared with New York Lorraine forms under the assumption of the upper Utica and Lorraine age of the beds. They have largely proven to be earlier species, especially so among the lamellibranchs. Unfortunately these earlier collections will not be accessible again for several years to come. Nevertheless the list gives a fair idea of the aspect and the size of the fauna of the Snake Hill beds. This large fauna has been greatly augmented and partly corrected by the later collections from Snake Hill itself, which are here listed as follows:

Dicranograptus nicholsoni *Hopkinson*	(c)
Diplograptus (Mesogr.) putillus *Hall*	(cc)
Corynoides *sp.*	(r)
Glyptocrinus *sp.*	(r)
Heterocrinus ? gracilis *Hall*	(c)
Cremacrinus *sp.*	(rr)

Carabocrinus *cf.* radiatus *Billings*	(rr)
Edrioaster saratogensis *nov.*	(r)
Paleschara ulrichi *nov.*	(r)
Schizocrania filosa (*Hall*)	(r)
Plectambonites sericeus typus (*Sowerby*)	(cc)
Plectorthis *sp. cf.* whitfieldi (*N. H. Winchell*)	(rr)
Dalmanella testudinaria (*Dalman*)	(cc)
Plaesiomys retrorsa (*Salter*)	(c)
Rafinesquina alternata (*Emmons*)	(c)
Clitambonites americanus (*Whitfield*)	(r)
Parastrophia hemiplicata *Hall*	(r)
Zygospira recurvirostris (*Hall*)	(r)
Whiteavesia cincta *nov.*	(r)
W. cumingsi *nov.*	(c)
Orthodesma ? subcarinatum *nov.*	(c)
Whitella elongata *nov.*	(r)
Clidophorus ventricosus *nov.*	(c)
C. foerstei *nov.*	(c)
Ctenodonta levata (*Hall*)	(c)
C. declivis *nov.*	(r)
C. prosseri *nov.*	(c)
C. radiata *nov.*	(r)
C. recta *nov.*	(r)
C. subcuneata *nov.*	(r)
Lyrodesma schucherti *nov.*	(rr)
Solenomya ? insperata *nov.*	(r)
Cuneamya acutifrons *Ulrich*	(r)
Archinacella orbiculata (*Hall*)	(c)
Cyclonema montrealense *Billings*	(r)
Cyclonema cushingi *nov.*	(r)
Clathrospira subconica *Hall*	(r)
Pterotheca *cf.* canaliculata (*Hall*)	(rr)
Eoharpes ottawensis (*Billings*)	(rr)
Trinucleus concentricus (*Eaton*)	(cc)
Proëtus undulostriatus (*Hall*)	(rr)
Calymmene senaria *Conrad*	(r)
Lepidocoleus jamesi *H. & W.*	(c)
Ctenobolbina subrotunda *Ruedemann*	(r)
Technophorus cancellatus *Ruedemann*	(r)

While the foregoing list cites only the fossils obtained on the cliff and slope of Snake hill, the cliff on the east shore of the lake, north of Snake hill, and the outcrops about Edgewater park on the west side have also furnished faunules that add to the Snake Hill congeries of species, especially to the graptolite biota:

Corynoides calicularis *Nicholson*	(cc)
Dicranograptus nicholsoni *Hopkinson*	(cc)

Glossograptus quadrimucronatus *mut.* pertenuis *Rued.*
Diplograptus amplexicaulis *Hall* (c)
D. amplexicaulis *var.* pertenuis *Rued.* (c)
D. (Mesogr.) putillus (*Hall*) (c)
Climacograptus scharenbergi *Lapworth* (r)
C. spiniferus *Rued.* (cc)
Plectambonites *sp.*
Archinacella orbiculata (*Hall*) (c)
Lepidocoleus jamesi *H. & W.* (c)

The combined fauna of the Snake Hill beds, as known at present, is:

1 Dicranograptus nicholsoni *Hopkinson*
2 Diplograptus amplexicaulis *Hall*
3 D. amplexicaulis *var.* pertenuis *Rued.*
4 D. (Mesogr.) putillus *Hall*
5 Climacograptus scharenbergi *Lapworth*
6 C. spiniferus *Rued.*
7 Cryptograptus tricornis *Carr. mut.* insectiformis *Rued.*
8 Lasiograptus eucharis (*Hall*)
9 Glossograptus quadrimucronatus *Hall mut.* pertenuis *Rued.*
10 Corynoides calicularis *Nicholson*
11 Dawsonia campanulata *Nicholson*
12 Glyptocrinus *sp.*
13 Heterocrinus ? gracilis *Hall*
14 Cremacrinus *sp.*
15 Schizocrinus nodosus *Hall*
16 Carabocrinus *cf.* radiatus *Billings*
17 Edrioaster saratogensis *nov.*
18 Pontobdellopsis cometa *Rued.*
19 Paleschara ulrichi *nov.*
20 Pachydictya acuta (*Hall*)
21 Lingula curta *Conrad*
22 Leptobolus insignis *Hall*
23 Pholidops trentonensis *Hall*
24 Schizocrania filosa *Hall*
25 Plectambonites sericeus typus (*Sowerby*)
26 Plectorthis *sp. cf.* whitfieldi (*N. H. Winchell*)
27 Dalmanella testudinaria (*Dalman*)
28 Plaesiomys retrorsa (*Salter*)
29 Plectorthis plicatella *Hall*
30 Platystrophia biforata (*Schlotheim*)
31 Rafinesquina alternata (*Emmons*)
32 Clitambonites americanus (*Whitfield*)
33 Rhynchotrema inequivalve (*Castelnau*)
34 Parastrophia hemiplicata *Hall*
35 Cyclospira bisulcata (*Emmons*)
36 Zygospira recurvirostris (*Hall*)

37 Whiteavesia cincta *nov.*
38 W. cumingsi *nov.*
39 Orthodesma ? subcarinatum *nov.*
40 Whitella elongata *nov.*
41 Clidophorus ventricosus *nov.*
42 C. foerstei *nov.*
43 Ctenodonta levata (*Hall*)
44 C. declivis *nov.*
45 C. prosseri *nov.*
46 C. radiata *nov.*
47 C. recta *nov.*
48 C. subcuneata *nov.*
49 Lyrodesma schucherti *nov.*
50 Solenomya ? insperata *nov.*
51 Cuneamya acutifrons *Ulrich*
52 Archinacella orbiculata (*Hall*)
53 Cyclonema montrealense *Billings*
54 C. cushingi *nov.*
55 Clathrospira subconica *Hall*
56 Protowarthia *cf.* cancellata (*Hall*)
57 Pleurotomaria *cf.* lenticularis (*Hall*)
58 Murchisonia (Lophospira) uniangulata *var.* abbreviata *Hall*
59 Orthoceras tenuitextum (*Hall*)
60 O. lineolatum (*Hall*)
61 Spyroceras bilineatum (*Hall*)
62 Conularia trentonensis *Hall var.* multicosta *nov.*
63 Pterotheca *cf.* canaliculata (*Hall*)
64 Eoharpes ottawensis (*Billings*)
65 Trinucleus concentricus (*Eaton*)
66 Proëtus undulostriatus (*Hall*)
67 Triarthrus becki *Green*
68 Isotelus gigas *Dekay*
69 Acidaspis trentonensis *Hall*
70 Calymmene senaria *Conrad*
71 Pterygometopus callicephalus (*Hall*)
72 Ctenobolbina ciliata (*Emmons*)
73 C. ciliata *var.* cornuta *Ruedemann*
74 C. subrotunda *Ruedemann*
75 Lepidocoleus jamesi (*Hall & Whitfield*)
76 Turrilepas ? filosus *Ruedemann*
77 Pollicipes siluricus *Ruedemann*
78 Technophorus cancellatus *Ruedemann*[1]

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[1] To this list have to be added a number of interesting species which were obtained by the writer when this paper was already in press, at the excavations for the shops of the Delaware & Hudson R. R. at

In comparing these faunas with that of the Canajoharie shale, we find that most graptolites of the two formations are but little different. Closer scrutiny shows, however, that the Snake Hill beds contain certain forms which do not appear in the Canajoharie beds. The most important of these are: Climacograptus caudatus, C. scharenbergi, Cryptograptus tricornis mut. insectiformis. On the other hand, Climacograptus mohawkensis and Diplograptus quadrimucronatus mut. cornutus are peculiar to the Canajoharie shale. But also the forms which are common to both, show a marked difference in their frequency. Thus of Dicranograptus nicholsoni[1] and Climacograptus spiniferus[2] which are among the most common graptolites of the Snake Hill beds about Saratoga lake, the former is extremely rare in the Canajoharie beds, and the latter only frequent in the lower portion of the Canajoharie beds, about Hudson Falls and Ballston. On the other hand, Lasiograptus eucharis is all but absent in the Snake Hill beds, but well established in the parallel belt of Canajoharie beds, and while Corynoides calicularis occurs in both, C. gracilis, which occurs in the Snake Hill beds in several localities, seems to enter only the lower portion of the Canajoharie beds about Hudson Falls.

Watervliet, N. Y. The species new for this formation collected there are:

Trematis terminalis *Emmons.* Large form approaching T. millepunctata *Hall*

Schizambon fissus *var.* canadensis *Ami.* Large, long-spined specimens

Lingula obtusa *Hall*

Cyrtolites trentonensis *Conrad.* Much flattened specimens

Carinaropsis cf. carinata *Hall.* Large specimens

[1] As we have already noted, this species ranges here even into the Indian Ladder shale. This corresponds to the great range of the species in Europe, where it is cited from the zone of Nemagr. gracilis (corresponding to our Normanskill shale) in Sweden and reaches into the Hartfell shale in Great Britain.

[2] Climacogr. spiniferus was at first distinguished by us as C. typicalis mut. spinifer (title 60, p. 411) to identify a form figured by Hall (title 3, pl. 73, fig. 2a) as coming from Ballston, Saratoga county and which we have found to mark the shales directly overlying the basal Trenton limestone (Glens Falls limestone) at Hudson Falls (Sandy Hill). On account of its stratigraphic importance and apparent constancy of characters for a considerable length of time we prefer to distinguish this type as of specific rank (Cl. spiniferus).

Much more distinct is the difference between the Snake Hill beds and Canajoharie beds in the nongraptolitic portion of the fauna; for the former formation contains a great number of species that have not been observed in the Canajoharie beds, the most important of which are Edrioaster saratogensis, Carabocrinus, Orthis (Plaesiomys) retrorsa, Parastrophia hemiplicata, Zygospira recurvirostris, the many species of lamellibranchs, the trilobites Eoharpes ottawensis, Proëtus undulostriatus, also Pollicipes siluricus, Technophorus cancellatus, and the ostracods. On the other hand, the Canajoharie beds also contain a number of species not found in the Snake Hill beds, as Hyolithes pinniformis, Pterinea (Prolobella?) trentonensis and Pterinea insueta and a number of ostracods (Ulrichia? bivertex, Primitia unicornis).

When we now turn to the question of the relative position of the Snake Hill beds to the Canajoharie beds, we find several lines of evidence.

1 The common occurrence of a great number of fossils in both, which are absent above and below these two formations, as Diplograptus amplexicaulis and Corynoides calicularis, would indicate that both are either subdivisions of one formation or were deposited nearly contemporaneously in adjoining areas. If they are subdivisions of one formation, the faunal evidence would indicate that the Snake Hill beds are the older formation, for they contain in Cryptograptus tricornis, Climacograptus caudatus, C. scharenbergi, Plaesiomys retrorsa, Parastrophia hemiplicata, Edrioaster, Eoharpes ottawensis, etc., elements that indicate early Trenton or Black River age.

2 Geographically the belt of Snake Hill shales lies between the Canajoharie shales on the west and the Normanskill shales on the east. Although the complex folding and faulting of this region is little favorable to the drawing of inferences from the relative positions of the belt, the general observations noted in Bulletin 42, that the older rocks are found in the east and the beds as a rule become successively younger toward the west in the overturned and overthrusted closed folds have thus far proved correct. On the east side of Saratoga lake the Snake Hill and Normanskill shales become

even interfolded so that they form narrow alternating strips. We therefore infer that the Snake Hill beds lie closer to the Normanskill shales than the Canajoharie shales and are older than the latter.

3 At Hudson Falls and near Saratoga the Canajoharie shales rest directly on the Glens Falls limestone. The latter is according to Ulrich's determination, of very early (basal) Trenton age.

Since now the Canajoharie beds rest directly on the Glens Falls limestone and the Snake Hill beds are older than the Canajoharie beds, they must be absent in the western part of the Saratoga basin as well as in the Mohawk valley. Because of the fact that the Snake Hill beds are interfolded with the Canajoharie beds at the lower Mohawk and the western edge of the Hudson valley, we have considered them at first as deposited about the eastern edge of the Mohawk basin and as intercalated there between the Glens Falls limestone and the Canajoharie shale. Subsequent work, however, especially the summer's work of 1911 on the Schuylerville sheet, has shown that these shales reappear in a distinct belt on the east side of the Normanskill belt. They are therefore deposits of the same basin as the Normanskill shale. This inference is in accord with the observation that nowhere Snake Hill beds have been observed between the Glens Falls limestone and the Canajoharie beds, and it also accords with the faunal evidence that the Snake Hill sea had connections toward the north and east and thence received an important portion of its fauna. This latter evidence consists in the presence in the shales of Edrioaster, Carabocrinus, Eoharpes ottawensis and Orthis (Plaesiomys) retrorsa, all of which point to the St Lawrence and Ottawa Trenton rather than to the central New York Trenton. It is also noteworthy in this connection that Proëtus undulostriatus, of which we have obtained a well preserved carapace in the Snake Hill beds, is also known from the black pebbles (Black river?) of the Rysedorph Hill conglomerate and that the latter in its faunal connections also points east. Likewise Climacograptus caudatus is in America known only from the Snake Hill beds and the Magog shales in Canada and is an Atlantic form. Cryptograptus tricornis and Climacograptus scharenbergi have been directly taken from the Normanskill sea.

SUMMARY

The conclusions obtained in the preceding paper are:

1 The lower part of the black shale belt of the lower Mohawk valley hitherto referred to the Utica shale is of Trenton age and therefore here distinguished as *Canajoharie shale* from its typical outcrop at Canajoharie. The Canajoharie shale corresponds roughly to the lower and possibly middle Trenton of Trenton Falls and probably belongs in large part between the two. It disappears westward and is eastward cut off by the Hoffmans Ferry fault, but reappears north of Schenectady from under the Schenectady beds and eastward in the folded shales of the Hudson valley, where it is recognized in the Rural Cemetery beds, formerly referred by the author to the Magog shale of Canada. This belt can in the Hudson valley be followed northward through Saratoga county to Hudson Falls, where it rests on Glens Falls (basal Trenton) limestone.

2 The typical *Utica shale* seems to disappear entirely as it approaches the Hudson valley, probably through nondeposition.

3 The Frankfort shale is absent in the lower Mohawk valley. The shales, hitherto referred there to the Frankfort formation, are of older age. The Frankfort formation, in its restricted conception, soon disappears to the east of the type section near Utica, probably by overlap, and does not seem to have at all extended into the Hudson and Champlain valleys. According to its meager faunule it corresponds to the middle division of the Eden shale at Cincinnati and it may also include the upper Eden.

4 The so-called Frankfort beds of the lower Mohawk have furnished a large fauna that is very distinct from that of the Frankfort shale. Its most striking elements are the *eurypterids* and the seaweed Sphenophycus, but it also contains a number of species that indicate that it can not be younger than upper Trenton age and probably belongs mainly below the upper Trenton. Since these beds are connected by transitional beds with the underlying Canajoharie shale of lower and middle Trenton age, the inference of their middle and upper Trenton age is also supported by the stratigraphic relations. The formation is therefore here given a new name, the *Schenectady* formation. This formation attains a great thickness (approximately 2000 feet) in the lower Mohawk region, but does not extend far westward and ends abruptly eastward against the folded region. It is characterized by numerous intercalations of "bluestone," a calcareous sandstone, by mud-cracks, rapid horizontal alteration of sediments and other features which indicate nearness of the coast. This coast was probably to the east and the great

thickness of the Schenectady beds in this region is due to their formation in a sinking trough parallel to and in front of the Green Mountain-Taconic fold system. The Schenectady beds strike for this reason from north-northeast to south-southwest.

5 The uppermost portion, about 300 feet, of the "Frankfort" beds at their eastern edge in Albany county has been found to contain an entirely different fauna and also to be lithologically somewhat different. This division has been termed here the *Indian Ladder beds.* These rapidly disappear westward, being absent at Cobleskill and probably formed originally a narrow belt extending north-northeast to south-southwest; they are hence for the greater part buried under Devonic rocks in the south, and lost by erosion north of the Helderbergs, and only exposed to view in the Helderberg escarpment. The Indian Ladder beds contain the fauna of the Southgate division of the Eden shale and are hence of the age of part of the Frankfort beds but entirely different from them in their faunal aspect.

6 The *Brayman shales* which were originally referred to the Clinton and later were correlated with the Salina, appear to be the residual pyritiferous clays of the long hiatus corresponding to the time interval from the upper Trenton Schenectady shale to the Cobleskill limestone. They seem, however, sufficiently closely connected with the underlying sandstone at the top of the Schenectady shale to be considered as mainly formed in Upper Ordovicic time.

7 In the Hudson valley a belt of slates, grit and sandstones extends between the Canajoharie shale and Normanskill shale. It is distinguished from both by its fauna, and from the Canajoharie beds in the character of the shale and the greater intercalation of arenaceous beds. This shale which in the Hudson valley is well exposed on Green island, opposite Troy, and at Mechanicville, has received the name *Snake Hill beds* from its very fossiliferous outcrops at Snake hill, on the east side of Saratoga lake. It exhibits in its fauna evidence of being older than the Canajoharie shale and younger than the Normanskill shale and also distinct relations to the basal Trenton of the Ottawa basin, and properly belongs to the Levis basin where it follows the Normanskill shale.

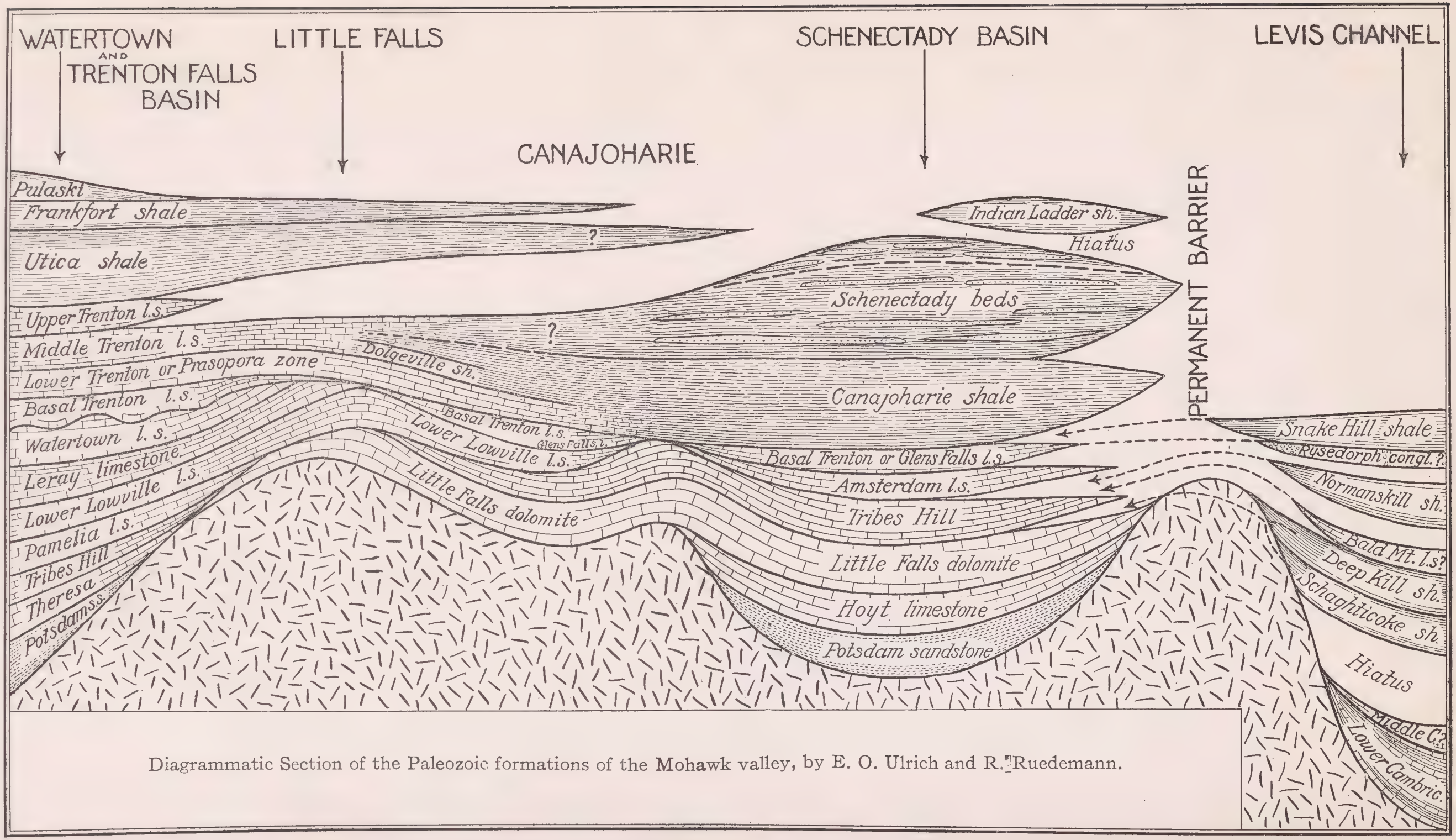
8 The Canajoharie, Utica and Frankfort shales seem to correspond to the three divisions of the Martinsburg shale of Pennsylvania, Maryland and Virginia, or to be a northern continuation of that formation; and the Frankfort shale can also be correlated with the middle part of the Eden shale of the Cincinnatian in Ohio.

Correlation table of the Cincinnatian and Upper Mohawkian groups of the Mohawk valley

OHIO VALLEY	UPPER MOHAWK VALLEY	LOWER MOHAWK VALLEY	PENNSYLVANIA–NEW JERSEY
Eden	Frankfort shale	Indian Ladder shale	
	Utica shale		
Trenton	Upper Trenton ls.	Schenectady beds	Martinsburg shale
	Middle Trenton ls.		
	Lower Trenton ls.	Canajoharie shale	
	Basal Trenton ls.	Glens Falls ls.	
Black River		Amsterdam ls.	Jacksonburg ls.
	Lowville ls.	Lowville ls.	

Table of the Cincinnatian and Upper Mohawkian in the Mohawk valley

SECTION	TRENTON FALLS–UTICA	DOLGEVILLE–LITTLE FALLS	CANAJOHARIE–SHARON SPRINGS	AMSTERDAM–COBLESKILL	SCHENECTADY–INDIAN LADDER
Cincinnatian	Frankfort shale	Frankfort shale	Frankfort shale?		Indian Ladder beds
	Utica shale	Utica shale	?		
Upper Mohawkian	Upper Trenton limestone		?	Schenectady beds	
	Middle Trenton limestone	" Utica shale "			
		Dolgeville beds	Canajoharie shale		
	Lower Trenton limestone	Lower Trenton limestone			
	Basal Trenton ls.	Basal Trenton ls.	Glens Falls ls.	Glens Falls ls.	Glens Falls ls.



Diagrammatic Section of the Paleozoic formations of the Mohawk valley, by E. O. Ulrich and R. Ruedemann.

Note to diagram

Doctor Ulrich and the writer have represented the stratigraphic results here obtained in the adjoined diagrammatic section of the Eopaleozoic formations of the Mohawk valley. The relations of the formations below the Trenton are reproduced as established through former investigations by E. O. Ulrich, H. P. Cushing and the writer. The relations of the Canajoharie and Schenectady beds to the Trenton limestone of the Trenton Falls basin are represented as described here. The upper Trenton limestone is drawn as abruptly terminating at the eastern edge of the Trenton Falls basin, because Doctor Ulrich failed to find it between Rathbone brook and Middleville, and the Utica shale is shown to diminish rapidly eastward, especially in its lower portion. The amount of its eastward extension in the Mohawk valley at present is not fully known. The Schenectady beds may at their top reach into the upper Trenton age and this transgression into the upper Trenton is indicated by the dotted line. The Indian Ladder beds appear as a lenticular body, since their main extension is in northeastern direction, crossing the east-west sectional plane in a very limited area.

Doctor Ulrich holds from his investigations that the Levis is the second trough east of the Schenectady basin and that the Chazy bay intervenes but is now covered by the overthrust Levis deposits. We have not attempted to introduce this condition on the diagram to the right of the permanent barrier because the exaggeration of the vertical scale would not permit its intelligible representation. The overthrust condition, however, which has brought the formation of the Levis basin in contact with those of the Schenectady basin in Albany and Saratoga counties, is indicated by the arrows showing the direction of the movement. We have further tentatively placed in the series of the Levis channel formations (mainly graptolite shales) a limestone outcropping about Bald mountain. From fossils collected last summer by the writer it is determined as of upper Beekmantown age. The Rysedorph Hill conglomerate, which also outcrops at various localities, belongs with the Levis channel graptolite beds and probably lies between the Normanskill shale and Snake Hill beds.

Bibliography

(1) 1842 **Vanuxem, Lardner.** Geology of New York; Report on the Third District.

(2) 1843 **Mather, W. W.** Geology of New York; Report on the First District.

(3) 1847 **Hall, James.** Palaeontology of New York. v. 1.
(4) 1858 **Billings, E.** On the Asteridae of the Lower Silurian Rocks of Canada. Can. Org. Remains. Dec. III, p. 75.
(5) 1865 **Billings, E.** Geology of Canada, Palaeozoic Fossils. v. 1.
(6) 1873 **Meek, F. B.** Descriptions of **Invertebrate Fossils of the** Silurian and Devonian Systems. Rep't, Geol. Surv. Ohio. v. 1, pt 2.
(7) 1877 **Whitfield, R. P.** In Lieut. G. M. Wheeler's Report on U. S. Geog. Surv. West of 100th Meridian. v. 4, Pal., p. 19–20
(8) 1879 **Ulrich, E. O.** Descriptions of New Genera and Species of Fossils from the Lower Silurian about Cincinnati. Jour. Cincinnati Soc. Nat. Hist. v. 2.
(9) **Walcott, C. D.** The Utica Slate and Related Formations of the Same Geological Horizon. Albany Inst. Trans. 10. 1–17.
(10) **Walcott, C. D.** Fossils of the Utica Slate. Albany Inst. Trans. 10:18.
(11) 1882 **Miller, S. A.** Description of Two New Genera and Eight New Species of Fossils from the Hudson River Group, with Remarks upon Others. Jour. Cincinnati Soc. Nat. Hist. 5:34.
(12) **Whitfield, R. P.** Geology of Wisconsin. v. 4, Paleontology.
(13) 1883 **Beecher, C. E.** List of Species of Fossils from an Exposure of the Utica Slate and Associated Rocks within the Limits of the City of Albany. 36th Annual Report N. Y. State Mus. Nat. Hist. p. 78.
(14) 1885 **Ford, S. W.** Age of the Slaty and Arenaceous Rocks in the Vicinity of Schenectady, N. Y. Amer. Jour. Sci. 29:397–99.
(15) 1889 **Ulrich, E. O.** Contribution to Canadian Micro-Paleontology, pt II.
(16) 1890 **Stürtz, B.** Bieträge zur Kenntniss palaeozoischer Seesterne. Palaeontographica. 36:234.
(17) **Walcott, C. D.** Value of the Term "Hudson River Group" in Geologic Nomenclature. Bul. Geol. Soc. Amer. 1:335–57.
(18) **Hall, James, & Clarke, J. M.** Palaeontology of New York. v. 8, pt. 1.
(19) 1893 **Beecher, C. E.** On the Thoracic Legs of Triarthrus. Amer. Jour. Sci., Ser. 3, v. 46, 1893; also Amer. Geol., v. 13, 1894; Amer. Jour. Sci., Ser. 3, v. 47, 1894; Amer. Geol., v. 15, 1895; Amer. Jour. Sci., Ser. 4, v. 1, 1896.
(20) **Clarke, J. M.** The Protoconch of Orthoceras. Amer. Geol. 12:112.
(21) **Matthew, W. D.** On Antennae and Other Appendages of Triarthrus becki. Amer. Jour. Sci., Ser. 3, v. 46.
(22) **Ulrich, E. O.** New and Little Known Lamellibranchiata from the Lower Siluric Rocks of Ohio and Adjacent States. Rep't, Geol. Sur. Ohio. v. 7.
(23) 1894 **Clarke, J. M.** The Early Stages of Bactrites. Amer. Geol. 14:37.

(24) Darton, N. H. Preliminary Report on the Geology of Albany County. 13th Annual Report N. Y. State Geologist. 1:229–61.

(25) **Darton, N. H.** Geology of the Mohawk Valley. 1: Herkimer, Fulton, Montgomery and Saratoga Counties. N. Y. State Geol. Rep't 13 (for 1893), p. 407.

(26) **Hyatt, Alpheus.** Phylogeny of an Acquired Characteristic. Proc. Amer. Philos. Soc. 32, no. 143.

(27) 1895 **Ruedemann, Rudolf.** Development and Mode of Growth of the Genus Diplograptus, McCoy. N. Y. State Geol. Rep't 14 (for 1894), p. 15, 217.

(28) **Ulrich, E. O.** Lower Silurian Bryozoa of Minnesota. Geol. Minn. v. 3, pt 1, Paleontology.

(29) **Winchell, N. H., & Schuchert, Charles.** The Lower Silurian Brachiopoda of Minnesota. Geol. Minn., v. 3, pt 1, Paleontology.

(30) 1896 **Harper G. W., & Bassler, R. S.** Catalogue of the Fossils of the Trenton and Cincinnati Periods, Occurring in the Vicinity of Cincinnati, Ohio. Cincinnati, 1896.

(31) **Gregory, J. W.** On the Classification of the Palaeozoic Echinoderms of the Group Ophiuroidea. Proc. Zool. Soc. London, 64:1035.

(32) 1897 **Clarke, John M.** The Lower Silurian Trilobites of Minnesota. Geol. Minn. v. 3, pt 2, Paleontology.

(33) **Prosser, C. S., & Cumings, E. R.** Sections and Thickness of the Lower Silurian Formation in West Canada Creek and in the Mohawk Valley. N. Y. State Geol. Rep't 15 (for 1895), p. 615.

(34) **Prosser, C. S., & Rowe, R. B.** Stratigraphic Geology of the Eastern Helderbergs. N. Y. State Geol. Rep't 17 (for 1897), p. 329.

(35) **Ruedemann, Rudolph.** Note on the Discovery of a Sessile Conularia. N. Y. State Geol. Rep't 15 (for 1895), p. 699.

(36) **Ruedemann, Rudolph.** Evidence of Current Action in the Ordovician of New York. Amer. Geol. 19:367.

(37) **Schuchert, Charles.** Synopsis of American Fossil Brachiopoda. Bull. U. S. Geol. Surv. 87.

(38) **Ulrich, E. O.** The Lower Silurian Lamellibranchiata of Minnesota; The Lower Silurian Ostracoda. Geol. Minn. v. 3, pt 2.

(39) **Ulrich, E. O., & Scofield, W. H.** The Lower Silurian Gastropoda, ibidem.

(40) 1898 **Whitfield, R. P., & Hovey, E. O.** Catalogue of the Types and Figured Specimens in the Paleontological Collections of the Geological Department, American Museum of Natural History, Bul. Amer. Mus. Nat. Hist. 11:1.

(41) 1899 **White, T. G.** Report on the Relations of the Ordovician and Eo-Silurian Rocks in Portions of Herkimer, Oneida and Lewis Counties. N. Y. State Mus. Rep't 51 (for 1897), p. 21.

(42) **Prosser, C. S.** Sections of the Formations along the Northern End of the Helderberg Plateau. N. Y. State Geol. Rep't 18 (for 1898), p. 51.

(43) **Jaekel, Otto.** Stammesgeschichte der Pelmatozoen. v. 1.

(44) 1900 **Cumings, E. R.** Lower Silurian System of Eastern Montgomery County, N. Y. N. Y. State Mus. Bul. 34, p. 415.

(45) 1900 **Prosser, C. S.** Notes on Stratigraphy of Mohawk Valley and Saratoga County. N. Y. State Mus. Bul. 34, p. 469.

(46) 1901 **Bather, F. A.** The Geologic Distribution of Pollicipes and Scalpellum. Science, n. s. 14:112.

(47) **Ruedemann, Rudolf.** Hudson River Beds near Albany and Their Taxonomic Equivalents. N. Y. State Mus. Bul. 42.

(48) **Ruedemann, R.** Trenton Conglomerate of Rysedorph Hill and Its Fauna. N. Y. State Mus. Bul. 49, p. 3.

(49) 1902 **Nickles, J. M.** The Geology of Cincinnati. Jour. Cinc. Soc. of Natural History. 20:49.

(50) **Pocta, Phil.** Ueber die Anfangskammer der Gattung Orthoceras Breyn. Sitzungsber. der K. böhm. Gesellsch. d. Wiss.

(51) **Ulrich, E. O., & Schuchert, Charles.** Palaeozoic Seas and Barriers in Eastern North America. N. Y. State Mus. Bul. 52, p. 633.

(52) 1903 **Clarke, J. M.** Classification of New York Series of Geologic Formations. N. Y. State Mus. Handbook 19.

(53) **Weller, Stuart.** The Paleozoic Faunas of New Jersey. Geol. Surv. of New Jersey, Rep't on Pal., v. 3.

(54) 1905 **Cushing, H. P.** Geology of the Northern Adirondack Region. N. Y. State Mus. Bul. 95.

(55) **Cushing, H. P.** Geology of the Vicinity of Little Falls, Herkimer County. N. Y. State Mus. Bul. 77.

(56) 1906 **Grabau, A. W.** Geology and Paleontology of the Schoharie Valley. N. Y. State Mus. Bul. 92.

(57) 1908 **Cumings, E. R.** The Stratigraphy and Paleontology of the Ordovician Rocks of Indiana. 32d Annual Rep't of the Dep't of Geology of Indiana.

(58) **Elles, G. L., & Wood, E. M. R.** Monograph of British Graptolites; ed. by C. Lapworth. Pt VI. Pal. Soc. for 1907; pt VII, 1908.

(59) **Kümmel, H. B.** Paleozoic Sedimentary Rocks in Franklin Furnace Folio, N. J.; U. S. G. S., Folio 161.

(60) **Ruedemann, Rudolf.** Graptolites of New York, pt 2. N. Y. State Mus. Mem. 11.

(61) 1909 **Stose, George W.** Mercersburg-Chambersburg Folio, Pa.; U. S. G. S. Folio 170.

(62) **Bassler, Ray S.** The Cement Resources of Virginia West of the Blue Ridge. Virg. Geol. Surv. Bul. 2.

(63) **Foerste, Aug. F.** Preliminary Notes on Cincinnatian and Lexington Fossils. Bul. Denison Univ. 14:289.

(64) **Miller, W. J.** Geology of the Remsen Quadrangle. N. Y. State Mus. Bul. 126.

(65) **Grabau, A. W.** Physical and Faunal Evolution of North America during Ordovicic, Siluric and Early Devonic Time. Jour. of Geol. 17:231.

(66) 1910 **Miller, W. J.** Geology of the Port Leyden Quadrangle, Lewis County, N. Y. N. Y. State Mus. Bul. 135.

(67) **Schuchert, C.** Paleogeography of North America. Bul. Geol. Soc. Amer., v. 20.

(68) 1911 **Ulrich, E. O.** Revision of the Paleozoic Systems, pts 1–3. Geol. Soc. Amer. Bul. v. 22, no. 3.

PALEONTOLOGICAL NOTES

Sphenophycus nom. prop.

The work in the Schenectady shales has brought to light a great quantity of finely preserved algal remains. In part these are identical with Sphenothallus latifolius, described by Hall from the top beds of the formation at Schoharie, but the greater part represents one or more different species, and many exhibit important features not shown by the original material. We should not have undertaken to describe these if we had not had the authoritative advice and encouragement of Mr David White regarding them, but we should have much preferred if Mr White would himself have agreed to write a note on these Lower Siluric algae.

Hall (title 3, p. 261) described the genus Sphenothallus as follows: "Plant consisting of a stem, with diverging wedge-form leaves, or of detached leaves having this form. Leaves apparently succulent or thickened, and sometimes subcoriaceous." He cites two species as belonging to it, viz, Sphenothallus angustifolius and S. latifolius. The former has been found by us as a rather frequent fossil in the Utica shale of Dolgeville and elsewhere and on reinvestigation (1897, N. Y. State Geol. Rep't 15) was referred to as a "sessile Conularia." The stem of the type specimen was found to be a cephalopod shell, to which the "leaves" are attached by basal disks. While we no longer consider this species as properly belonging to the genus Conularia itself, there is no doubt in our minds of its taxonomic position with the Conularidae. It therefore can not be retained in the same genus with the other species, S. latifolius, if the latter is an alga, and the question arises which of the two should retain the generic name Sphenothallus. S. angustifolius is the first species described under the diagnosis and moreover the latter is

clearly shaped principally after this species. If, therefore, S. angustifolius is a conularid, but not congeneric with Conularia, it should retain the generic name and a new one be selected for the second species. We therefore propose here the name *Sphenophycus* for the second species.

Both Sphenothallus angustifolius and Sphenophycus latifolius possess remarkably thick carbonaceous tests. That of Sphenothallus angustifolius also contains phosphate of lime and has the appearance of having originated from a chitinous or conchiolinous substance. Following a suggestion of Mr White, I tested the organic matter of Sphenophycus by fire and found that it burns with a fair degree of completeness, leaving an ash residue consisting of clay and silica and probably resulting from silt infiltration into the canals of the organism. This evidence suggests the vegetable nature of the carbonaceous tests.

The most remarkable portions of these vegetable remains are the club-shaped bodies reproduced on plate 2, figures 1–13. These were all obtained in one block that had fallen from the cliff overhanging the Mohawk river at Aqueduct. They consist of an elliptical or circular distal smooth body borne on an equally smooth pedicel. The distal body is in well-preserved specimens flattened at the apex and in some this part is infolded. The wrinkles and partial sections prove that the distal bodies were originally more or less inflated and the pedicel tubular (see section, plate 2, figure 8). The outline of these problematic fossils, a large number of which were obtained from the block, proved suggestive of a variety of animal objects, notably of chimaeroid, gastropod and cephalopod egg-cases, all of which suggestions were disproved by the kind advice of Messrs Bashford Dean, Gratacap and Pilsbry. Mr White has expressed the opinion to us that these bodies are algal flotation appendages. A specimen was observed showing these bladders attached to a spirally arranged group of the thalli of a Sphenophycus. It broke when lifted up; the portion saved is reproduced on plate 2, figure 13. This specimen and the apparent absence of any apertures of the bulbs or of any substance originally inclosed within them, are strong arguments in favor of that view. Likewise, the absence of any coarser surface sculpture on the bulbs, the extreme length of the pedicels in some and its unvaryingly torn proximal extremity, as well as the fibrous character of the pedicel seen in some examples, and the auxiliary bulblike inflations (see plate 2, figure 11) in the pedicel, point to the vegetable origin of these

fossils and their character of flotation appendages. We are not sure yet to which of the two species here distinguished they belong, although the present evidence indicates that they are referable to S. latifolius.

Several specimens of S. latifolius appear at first glance lobate (see plate 1, figure 1). It has been pointed out to me by Mr White that this appearance is due to the presence of cuplike marginal cavities and that these are apparently connected with the neural system which is canalicular. These cups and the canals are well seen in plate 1, figure 2.

Besides the genotype, S. latifolius, which according to the original description possesses "broadly cuneate thalli,[1]" we have distinguished a second species, but there are probably more than two species present, as indicated by such thalli as those reproduced in plate 1, figure 9. The cuneate thalli of S. latifolius were probably arranged spirally around a stem, as indicated by their wedgelike shape and by the specimen plate 1, figure 13.

The largest thalli found are those typically represented by plate 1, figure 5. While also possessing a broadly cuneate to trapezoidal outline, they are not single as those of S. latifolius, but, as again pointed out to us by Mr White, "composed of rather slender, but rigid conical thalli, originating at the scarlike pits or depressions of the lower parts of the axis."

A third type is represented by plate 1, figure 9. Only one specimen of this interesting form has been thus far obtained. It shows a pitted middle axis from which proceed lobate thalli, ornamented with broadly recurving lines. This material we consider too imperfect for specific differentiation.

Cyathodictya ? tubularis nov.

Certain layers of the Canajoharie beds at Canajoharie are covered with multitudes of small elongate bodies which contrast by their brown coloring with the black shale. These bodies are mostly about 5 mm long and then regularly conical in outline, but reach as

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[1] The original description is: "Leaves broadly cuneate, somewhat thickened at the outer margin, and truncate at the lower extremity; surface obscurely striated. The specimens are often marked on one side by a ridge or midrib along the center, and sometimes transversely wrinkled. These leaves all appear to have been thick and succulent, like the Fuci."

much as 15 mm in length and these larger specimens are cylindrical in outline. While completely flattened out, the roundish aperture at one end and the thickened lateral margins demonstrate that the bodies were originally tubular and rather thick-walled. The proximal end fades out in most specimens; in many others it is jagged as if broken off and in a few it contracts to a blunt point. The long tubular specimens show no appreciable contraction at either end.

Fig. 8

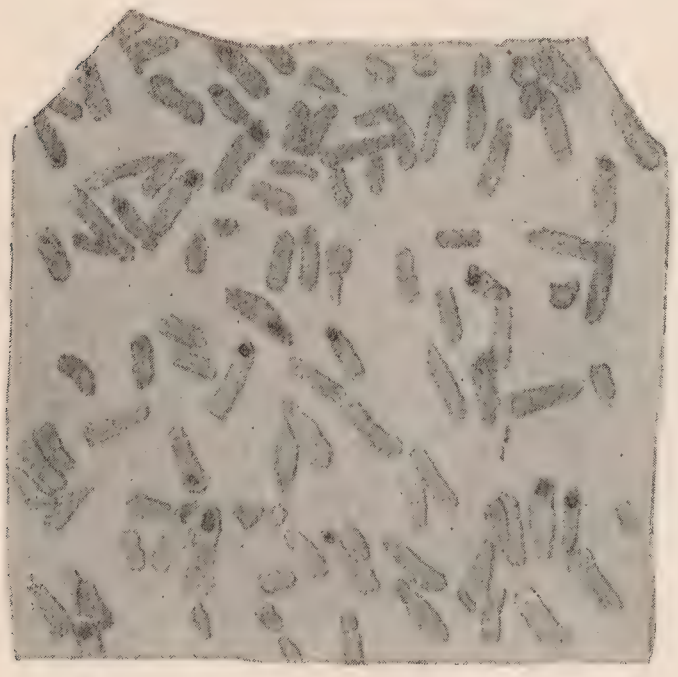

Fig. 9

Fig. 12

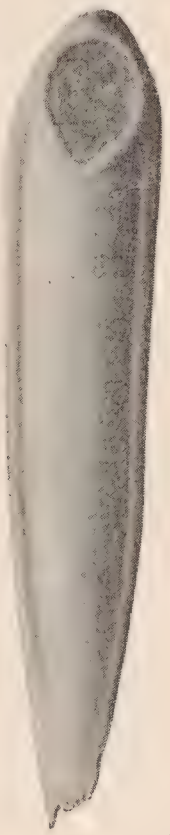

Fig. 10

Fig. 11

Fig. 8–12. Cyathodictya ? tubularis nov.

Fig. 8. Group of specimens of usual size. Natural size. Fig. 9. Group of large specimens. Natural size. Fig. 10. Specimen showing aperture, x 5. Fig. 11. Specimen showing spicules, x 5. Fig. 12. Fairly perfect specimen. Type, x 5.

Canajoharie shale at Canajoharie, N. Y.

The substance of the fossil is preserved and this as well as the thick margins show the walls to have been quite substantial.

We have referred this gregarious organism with doubt to Cyathodictya largely on account of the form and thick walls of the bodies. Owing to their small size we have not been able to satisfy ourselves as to the presence of spicules although delicate lines suggesting these are seen in some places on the walls, the longitudinal

spicules being more distinct in some, the transverse in others. Larger dictyonine spicules (typical hexactines), corresponding in size to those of the Utica species C. reticulata (Walcott) have been found in adjoining layers, demonstrating the actual presence of dictyosponges in these beds.

Fig. 14

Fig. 13

Fig. 15

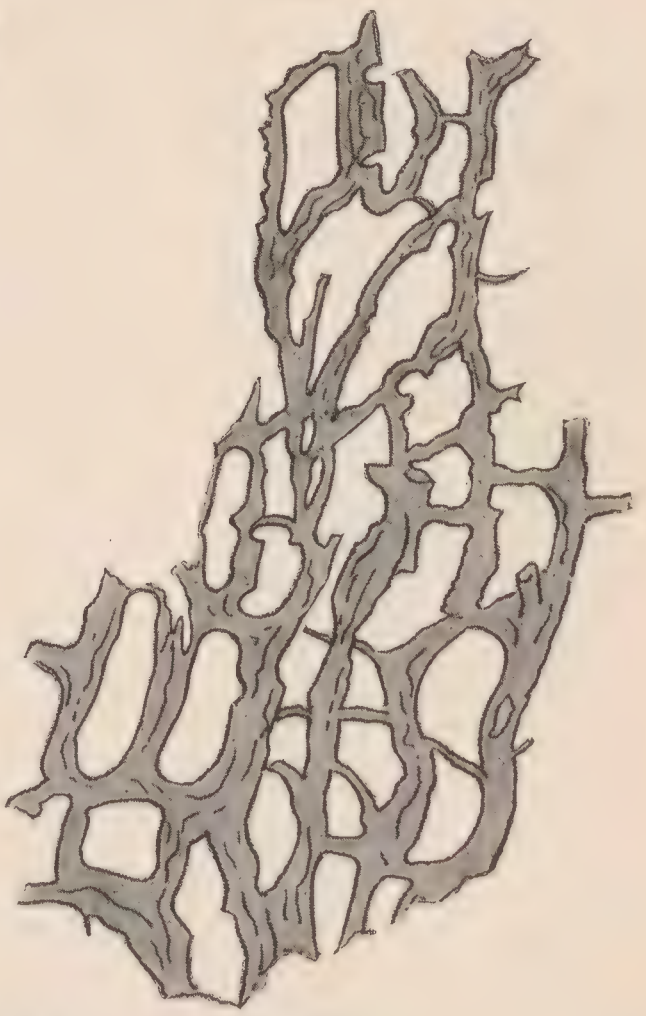

Fig. 13–15. Dictyonema arbuscula (Ulrich)

Fig. 13. Small rhabdosome, x 5. Fig. 14, 15. Fragments of distal portions of larger rhabdosomes, x 5.

Indian Ladder beds, at the Indian Ladder, N. Y.

Dictyonema arbuscula (Ulrich)

Pl. 2, fig. 15

A small Dictyonema was found to be not infrequent in the Indian Ladder shale at the Indian Ladder, which proved to be identical with a species hitherto recorded only from the Eden (formerly Utica) shale of the neighborhood of Cincinnati. According to Doctor Ulrich this species occurs in the Middle Third of the Eden shale. It was first described and figured in 1879 (title 8, p. 28) and also

noted in the Graptolites of New York, part 2 (title 60, p. 151). Like other Dictyonemas this species also shows a tendency to undulating, alternatingly adnascing branches in the proximal portion, giving that part a Desmograptuslike aspect, while it is a typical Dictyonema in the distal portions (see text fig. 13).

Dictyonema multiramosum nov.

Pl. 2, fig. 16

Description. Rhabdosome of small size (32 mm high) apparently cyathiform, arising from a short thick stem. Branches extremely thin and closely arranged, about .5 mm apart and .2 mm wide, bifurcating at frequent intervals, slightly undulating; mostly of rather straight appearance, frequently coalescing where brought in contact by the wavy form of the branches, or where the latter are straight, with thin dissepiments in long intervals. Thecae not clearly seen.

Fig. 16. Dictyonema multiramosum nov.

Portion of rhabdosome, x 5.

Schenectady beds, Rotterdam Junction, N. Y.

Horizon and locality. Schenectady beds near Rotterdam Junction, N. Y.

Remarks. But a single specimen of this species was obtained and this being inclosed in a sandy shale, is far from perfect in preservation. It is therefore possible that the species should be rather referred to Desmograptus which it approaches in some portions of the frond.

We have not observed any species in either the Trenton or Utica shales which approaches D. multiramosum in the extreme delicateness of the rhabdosome.

Dicranograptus nicholsoni Hopkinson var. **parvulus** nov.

The Canajoharie shale at Morphy's creek near Pattersonville, N. Y., contains in its basal layers, within a few feet of the underlying Glens Falls limestone a diminutive form of Dicranograptus nicholsoni which deserves recognition as a variety, as all the specimens of this bed retain uniformly their peculiar character.

The main differences from the typical nicholsoni are the closer arrangement or smaller size of the thecae, which number 14 in 10 mm, and the greatly varying length of the biserial portion (4–11 mm). The form of the thecae does not seem to differ from that of the larger types. The biserial portion has been seen in only one specimen and in this the axillary angle is smaller than in nicholsoni typus, namely about 10°.

The width of the stipe is not materially different from that of nicholsoni.

The most remarkable feature of the specimen retaining the biserial portion is the continuation of the axes of the biserial branches in antisicular direction. These axes have to our knowledge not been observed in either Dicellograptus or Dicranograptus outside of the theciferous portion. The free portions are too long and delicate to have been theciferous and to have secondarily become separated from the thecae. The rhabdosome of Dicranograptus was hence suspended from two axes which, as the parallel and slightly convergent final direction of the axes suggests, proceeded from a common initial point.

The specimen exhibits also a large "web" between the branches.

Dicellograptus nicholsoni possesses in the slate belt of New York a much larger *vertical range* than we had inferred in Memoir 11, page 318. We had cited it there from the "Trenton shales" (Normanskill shale) in several varieties and in typical development from the Utica of South Trenton, the Mohawk valley and the shales at Saratoga lake, which were also supposed to be of Utica age. The shales which carry D. nicholsoni in the Mohawk valley are in the present paper referred to the Trenton as Canajoharie shale and those at Saratoga lake are also correlated with the Trenton as Snake Hill beds. The Normans-

Fig. 17

Fig. 18

Fig. 17, 18. Dicranograptus nicholsoni Hopkinson var. parvulus nov.

Fig. 17. Specimen showing axes or nemacauli, x 5. Fig. 18. Long biserial portion of specimen showing form of thecae, x 5.

Canajoharie shale, Morphy creek, N. Y.

kill shale is now considered as being as old as the Chazy formation. We have also found a specimen in the Indian Ladder beds. This species ranges therefore in the shales of Eastern New York from the Chazy formation to the top of the Lower Siluric.

Diplograptus (Mesograptus) putillus Hall

Hall originally described as Graptolithus putillus in the Canadian Organic Remains, decade 2, a small graptolite from the "Hudson River group" of Iowa, that afterward was found to range through the Eden beds of Ohio (title 49, page 68) and to occur in many localities in the Utica shale of New York (title 60, page 416). Our subsequent work has shown that this minute type ranges in several mutations which are especially characterized by different size, from the Normanskill shale through the Snake Hill beds, the Canajoharie shale into the Utica shale. One of these (from the Normanskill shale) has been distinguished before as Climacograptus putillus mut. eximius (op. cit. page 420). Also the mutation of the true Utica horizon is distinguished by extremely small size, while those of the Canajoharie and especially the Snake Hill beds are remarkable for their greater size. It must be these larger mutations which characterize in Sweden a zone below that of Diplograptus quadrimucronatus.

The species has been currently referred to Diplograptus, while the present writer placed it in the Graptolites of New York with Climacograptus on account of the frequent Climacograptus aspect of the rhabdosomes. Part 6 of the "British graptolites" by Lapworth, Elles and Wood (title 58, page 256), proposes the subgenus Mesograptus for "forms in which the appearances presented are in part those characteristic of a typical Diplograptus (Orthograptus) and in part those more characteristic of a typical Climacograptus." It would seem that the subgenus Glyptograptus also contains forms quite similar to our species.

Diplograptus (Mesograptus) mohawkensis nov.

Pl. 2, figs. 18, 19

Diplograptus foliaceus (in part) *auctorum.*

Rhabdosome small, about 15–22 mm in length and 1.5–2 mm in width; the latter rapidly attained (in about 3 mm), in the largest specimen again narrowing in antisicular direction. The sicula has

not been observed; the virgella is stout and 1.5 mm long. Thecae 12–14 in 10 mm; having the Climacograptus aspect in both views in the proximal narrowed portion and throughout in the obverse aspect, and the Diplograptus aspect in the reverse aspect; having an average length of 1.5 mm and overlapping one-half of their length. The first thecae are narrow and with their outer walls but slightly inclined to the axis, the later thecae have oblique straight ventral margins in the reverse aspect and sigmoidal ventral margins in the obverse aspect. The excavation in the latter aspect is fairly deep (one-fourth the width of the rhabdosome); the apertural margin nearly straight.

Horizon and localities. In the lowest part of the Canajoharie shale at Morphy's and Swartztown creeks near Amsterdam, N. Y., and at the Carlsbad spring near Saratoga, N. Y.

Remarks. This species is one of the various forms that have been referred in our shales first to Diplograptus pristis Hall, and later to D. foliaceus Murchison; but it is readily distinguished from the rest by the striking difference in the two aspects, the obverse which is that of a Climacograptus, and the reverse which is that of a Diplograptus. In the Monograph of the British Graptolites the subgenus Mesograptus is proposed for that group of Diplograpti in which the stipe is conspicuously concavo-convex in section and the appearance of the thecae different in the two aspects. In the second of the two groups again distinguished under the Mesograpti, the excavations of the Climacograptus aspect are deep and conspicuous throughout. This condition, for which the subgenus Amplexograptus is proposed, is approached, if not reached, by the present form, although the excavations are not as deep as in the typical Amplexograpti.

[Fig. 19 Fig. 20

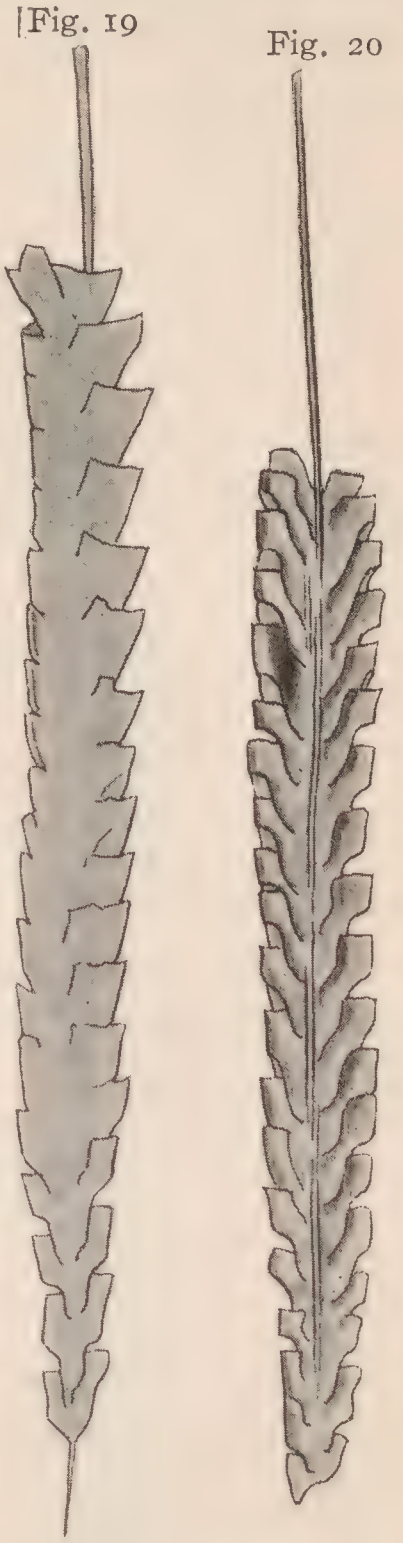

Fig. 19, 20. Diplograptus (Mesograptus) mohawkensis nov.

Fig. 19. Reverse aspect, x 5. Swartztown creek, N. Y.

Fig. 20. Obverse aspect, x 5. Carlsbad Spring near Saratoga, N. Y.

The species occurs almost to the exclusion of others and in profuse numbers in the basal beds at Swartztown creek and Morphy's creek and is quite obviously characteristic of the lowest zone of the

Canajoharie beds. It reaches there but 15 mm in length, and appears to have possessed a rather tenuous periderm. At the Carlsbad spring the specimens reach a greater size. From the geographic position of these latter shales near the Glens Falls belt of Rowland mills, we infer that these shales also lie near the base of the Canajoharie beds.

From the typical Diplograptus (Mesograptus) foliaceus this species is distinguished by its smaller size, narrower sicular portion and the stronger sigmoidal curvature of the ventral walls of the thecae in the obverse aspect. It does not seem, however, to be nearer related to any of the other British Lower Siluric Diplograpti.

Diplograptus (Amplexograptus) macer nov.

Pl. 2, figs. 20, 21

Description. Rhabdosome slender, 20–25 mm long with a maximal width of 1.5 mm, which is very gradually attained. Sicula not observed. Virgella small and inconspicuous. Thecae 12–14 in 10 mm, about 1.5 mm long, inclined 10°–12°, overlapping about one-half their length, with fairly straight or slightly sigmoidal ventral and straight to slightly concave apertural margins on the reverse aspect and straight vertical ventral margins and deep (one-third the width of rhabdosome) apertural excavations on the obverse aspect.

Horizon and locality. The top beds of the Canajoharie shale in the Minaville section are characterized by this species.

Remarks. D. macer is easily distinguished from the other Diplograpti of the "Utica" shale by its narrow, slender form, the closely arranged thecae and the very different appearance of the two sides; the rather deeply notched obverse aspect being especially easy of recognition. This aspect characterizes the species as falling within the subgenus Amplexograptus of Diplograptus. It would seem to be a further development of that of the earlier D. mohawkensis.

This species is in many features very similar to D. (Amplexograptus) arctus Elles & Wood, an earlier British form of the Dicranograptus shales, and is possibly a later mutation of the latter. The principal distinguishing features are the larger size and the long virgella of D. arctus.

Diplograptus vespertinus Ruedemann

In the Graptolites of New York, Memoir 11, page 352, the author has distinguished a form as mut. vespertinus of Diplograptus foliaceus Murchison, occurring typically in the

Fig. 22

Fig. 21

Fig. 23

Fig. 21, 22. Diplograptus (Amplexograptus) macer nov.
Fig. 21. Reverse aspect. Fig. 22. Obverse aspect. Both x 5.
Canajoharie shale, Minaville, N. Y.

Fig. 23. Diplograptus peosta Hall.
Specimen from Indian Ladder beds at the Indian Ladder, N. Y. x 5.

"Utica shale" of the Mohawk valley and Hudson valley, and the Lorraine beds. More recent work in these shales has shown that

it will be necessary to distinguish these Diplograpti more sharply if they are to be of any use in the elaboration of the stratigraphy of the shales. We therefore for the present restrict vespertinus to the forms from the Canajoharie shale. Since Diplograptus foliaceus Murchison, as since emended by Elles & Wood, clearly represents a different type, we recognize D. vespertinus as a distinct species.

Climacograptus spiniferus Ruedemann

We comprise under this name the form which in the Graptolites of New York, part 2, page 411, had been described as C. typicalis mut. spinifer from the shales at Ballston, Saratoga and Bakers Falls (now Hudson Falls). This type is a common and characteristic graptolite of the Canajoharie shale where C. typicalis is absent; it also occurs in the Snake Hill shale and enters into the Schenectady beds. It is therefore in its range, as also in its characters, so very distinct from C. typicalis that it should be recognized as a different species. I learn from Doctor Ulrich that it also is a characteristic graptolite of a part of the Martinsburg shale. The Mohawkian mutations of C. bicornis (a Normanskill species) that have been cited by several authors, the present included, probably all belong to spiniferus.

Lasiograptus (Thysanograptus) eucharis (Hall)

This minute form, which is remarkable for the frequent occurrence of entire colonies or synrhabdosomes, was originally described by Hall as a Retiograptus, later, on account of the form of the thecae, referred by the present writer to Diplograptus and in the Graptolites of New York, part 2, page 397, brought with doubt under Glossograptus. Last summer's investigation of the shales of the Mohawk valley has afforded the writer a few specimens from the Canajoharie shale of the Chuctenunda section and the Schenectady shale of Schenectady, which at last establish the generic position of this species. While those from the Chuctenunda reveal the marginal lacework characteristic of Lasiograptus, the specimens from Schenectady are partly pyritized and retain the fibrous thickenings of the angles of the thecal walls (see text figure 24).

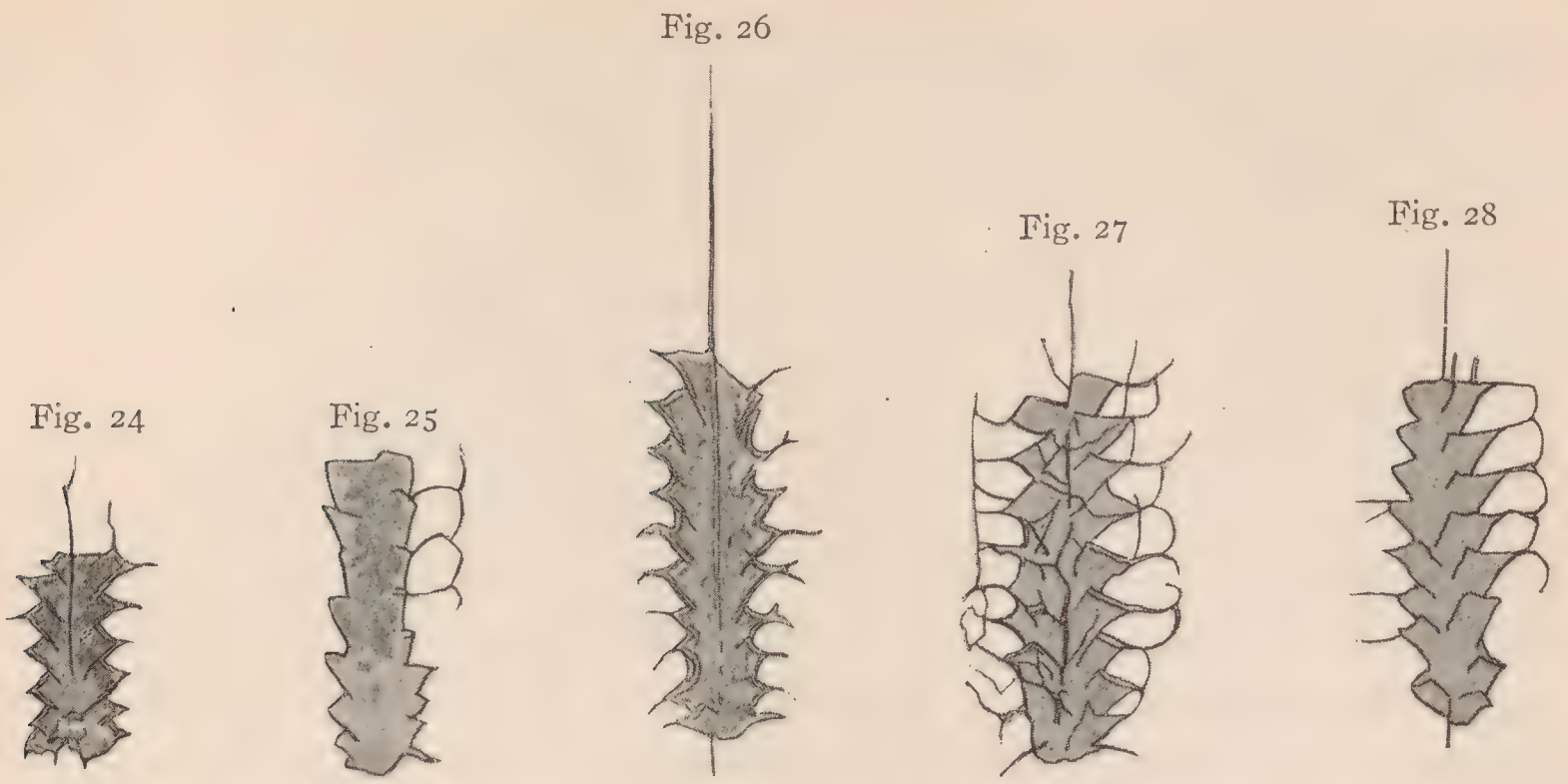

Fig. 24–28. Lasiograptus (Thysanograptus) eucharis (Hall).

Fig. 24. Pyrityzed specimen showing fibrous thickenings of the margins. Fig. 25. Specimen showing traces of the extra marginal lacework (lacinia). Fig. 26. Specimen showing pyritized marginal thickenings and ventral processes. Fig. 27. Specimen with fairly complete lacinia. Fig. 28. Specimen with a different aspect of the lacinia. All x 5.

Originals of Figs. 24 and 26 from Schenectady beds of Dettbarn quarry near Schenectady, N. Y.; those of Figs. 25, 27, 28 from Canajoharie shale Chuctenunda creek near Amsterdam, N. Y.

The genus Lasiograptus has been extended by Elles and Wood in their splendid Monograph of the British Graptolites (title 58, page 318), and several subgenera distinguished. Our species would correspond to their subgenus Thysanograptus in which the thecae are of the typical Amplexograptus form, and the ventral processes unite to form a complete ventral lacinia. In its general dimensions L. eucharis resembles the British L. harknessi Nicholson; it is, however, distinguished by the closer arrangement of the thecae.

In the Monograph of the Graptolites of New York, volume 2, L. eucharis is cited as occurring in the Utica shale and the "Trenton-Utica transition beds" of Panton, Vt. In our work, carried on since the publication of that volume, we have found that species also in the Snake Hill and Canajoharie shales which are of Trenton age and in the Frankfort shale, so that the range of L. eucharis is found to extend both below and above the Utica shale.

Glyptocrinus sp.

The presence of a species of Glyptocrinus in the Snake Hill sandstone is proven by a calyx and numerous stems with the characteristic alternation of larger and smaller joints. The calyx was about

the size of that of G. decadactylus and while distinctly showing the numerous interbrachials of Glyptocrinus, it is not well enough preserved for close determination.

Heterocrinus ? gracilis Hall

Pl. 3, fig. 5

Hall (title 3, page 280, plate 74, figure 3) describes and figures as Heterocrinus? gracilis an extremely small, slender crinoid, of which he states that " it occurs in the soft olive shale at Snake hill, Saratoga county, N. Y." Since Hall was unable to make out the arrangement of the calyx-plates, the species can not be considered as properly defined. It is, however, obvious to the collector that the shale, and especially a thin, dark gray sandstone bed at Snake hill, contains this and other coarser crinoids in considerable number. Unfortunately we have been unable thus far to obtain satisfactory material. We figure here a specimen of H. ? gracilis which permits a view of a part of the calyx, but defer the generic determination of this minute crinoid until better material has been obtained.

Cremacrinus sp.

Doctor Ulrich has kindly directed my attention to the presence of a specimen of Cremacrinus in the shaly Snake Hill sandstone. The specimen probably represents a new species since the calyx and whole body are more slender than the other congeneric forms; but we do not feel warranted, with the incomplete material before us, to do more at present than note the presence of this genus in the Snake Hill beds.

Carabocrinus cf. **radiatus** Billings

Pl. 3, fig. 6

The citation of this species among the Snake Hill fossils is based upon a single calyx plate which well exhibits the characteristic angular radiating sculpture lines of that species and corresponds to the basals (subradials) in outline. C. radiatus is known from the Trenton limestone of Ottawa.

Edrioaster saratogensis nov.

Pl. 3, figs. 2–4

Body of small size, about 14 mm in diameter, discoid, gently convex on the oral side; aboral surface not seen; apparently not attached.

Thecal plates irregular polygonal, mosaic, disposed without order and of small number; their surface granulose. Usually three or four large plates in the interambulacra, the marginal plates not seen.

Rays five, four solar and one contrasolar, broad and nearly straight in the proximal half, the extremital part rather abruptly bent and terminating within the disk subparallel to the margin. Oral aperture elongate, two rays arising from one, and three from the other end, surrounded by (five?) triangular oral plates with raised lateral edges. Ambulacra covered by two rows of alternating, inwardly converging, contiguous narrow plates with flat, horizontally extended tops. Subambulacral plates polygonal, as the thecal plates, but smaller, apparently hexagonal (the outer margins not clearly seen). Cover plates granulose, as the thecal plates. Anal pyramid small, consisting of four triangular plates, situated as in Agelacrinites, between the distally approaching or overlapping pair of solar and contrasolar rays.

Horizon and locality. Snake Hill shale and sandstone at Snake hill, Saratoga county, N. Y.

Remarks. This small and interesting type occurs only in molds in graywacke sandstone, which has been found loose in slabs under the cliff on the shore of the lake but not in place. Altogether four specimens were obtained by me.

The species is clearly congeneric with E. bigsbyi Billings, from the Trenton of Ottawa. It agrees exactly with that species, and since the latter is the type of the genus, also with the genus, in the form of the ambulacra and their coverplates, the form of the tegal plates and their sculpture. The oral and ambulacral plates, as well as the anal pyramid of Edrioaster bigsbyi have not yet been described and it is therefore still possible that they differ in the genotype, and the reference of our species to Edrioaster is doubtful in that respect.

Billings described E. bigsbyi as possessing four rows of pores in the ambulacra. Jaekel (title 43, page 44) has pointed out that these pores, if they existed, had probably nothing to do with the pores of the Cystoidea, but only served for the entrance of water into the vectacle furrows or for the discharge of sexual products. In E. saratogensis the cover plates fit snugly against each other wherever well preserved and have straight lateral sides, leaving no room for pores. In a few places, however, where the plates are apparently somewhat abraded, they are contracted in the middle, leaving long elliptic depressions between them.

Jaekel refers a second species, E. buchianus Forbes sp. (from Bather's ms.) to Edrioaster, basing his generic description on both forms. He describes the body as spherical from the cast of E. buchianus. E. saratogensis appears as a low spherical segment, but there is evidence of a flattening of the body in the pushing of plates over each other, and since the underside is not preserved in our material, it is possible that E. saratogensis also was originally spherical.

The direction of the spiral course of the ambulacra was in E. saratogensis apparently already fixed in distinction to E. bigsbyi, where it could be solar or contrasolar; and it has already reached the condition of the ambulacral rays of Agelacrinites.

The anal pyramid of E. buchianus is, according to Bather, surrounded by irregular plates. Also in this character E. saratogensis would seem to have advanced somewhat in showing a regular pyramid.

We have seen nothing that could be recognized as a madreporite.

All three known species of Edrioaster are of approximately the same age.

Taeniaster schohariae nov.

Pl. 3, fig. 1

This interesting species of Paleozoic Ophiuroidae or brittle stars, is based on a single individual, retaining three arms, one of which presents the ventral view and the other two their lateral views, resp. sections. The specimen is small, the arms about 15 mm long, and it is without a disk. The arms are slender and flexible, about 1.3 mm wide at the base, and almost as high in lateral view, originally probably cylindrical. The ventral view shows a straight or slightly zig-zagged ambulacral canal, and on both sides of this squarish depressions surrounded by the ambulacral and adambulacral ossicles, the covering lower arm plates not being retained if they existed. The inner (ambulacral or vertebral) ossicles appear as narrow and outwardly curved ridges, the outer or adambulacral ossicles as ridges bent in the opposite direction with a projection in the middle of the outer arch. The ambulacral ossicles are not directly opposite nor regularly alternating, but those of the right side on the ventral view advanced about one-third the length of the ossicles beyond those of the other side.

The lateral view of one other arm exhibits the ossicles as vertical bars, that are thickened at both ends resembling vertebrae and terminating at the dorsal side with a flat surface and forming there an apparently continuous layer. They appear almost twice as wide as the intervening spaces. The dorsal surface bears bundles of obliquely forward directed spines, one bundle corresponding to each ossicle. These spines appear in the right arm to proceed from small spine-bearing plates attached to the adambulacrals, as in the closely related Bundenbachia. On one arm two bundles are seen to proceed from each segment, one oblique, the other vertical to the arm. The oral skeleton consists of stout, bifid pieces, much resembling the oral pairs of adambulacrals of the genotype.

Horizon and locality. Upper Schenectady beds near Schoharie Junction, Schoharie county, N. Y.

Remarks. The genus Taeniaster was founded by Billings (title 4, page 80) on the Trenton species T. spinosus and T. cylindricus. The latter of these species has been made the type of the new genus Taeniura by Gregory (title 31, page 1035); Parks[1] however has pointed out that from inspection of Billings's type specimen he would rather refer the species to Lapworthura, Gregory. However that may be, we will consider here the genus Taeniaster as represented only by T. spinosus and T. elegans Miller. In that case our specimen would show the same general form and arrangement of the ossicles as both these species, but differ from both by its more slender arms. The shape of the ossicles resembles especially those of Taeniaster elegans, as figured by Miller,[2] but we presume that Miller's figure is somewhat diagrammatic. Parks states that T. elegans would seem to be a true Protaster, but for the fact that no disk is present. The same would be probably true of our species, for Parks's figure 4, giving the ventral view of an arm, presents a picture well comparable to the view of our middle arm, in the shape and arrangement of the ossicles, with the difference that the latter in our specimen appear much thinner.

There is no evidence observable in our specimen of any other plates but the so-called vertebral ossicles with the possible exception of the spine-bearing ossicles; it is therefore probable that T. schohariae possessed only this interior skeleton and no covering plates, a feature which is claimed by Stürtz (title 16,

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[1] Canadian Institute, Trans. 1907–8, 8: 371.

[2] Jour. Cinc. Soc. Nat. Hist. v. 5, 1882, pl. 1, fig. 6.

p. 234) for the whole suborder Ophio-encrinasteriae. Gregory, however, states that the true Taeniaster is asteroid in oral armature, in its alternately arranged ambulacral ossicles and in the absence of a disk.

Stürtz, *ibidem,* points out that Taeniaster and Bundenbachia exhibit a flexibility of the arms vertically to the disk which is among recent ophiurans found only in Ophiotholia. Our specimen is also preserved in a lateral view showing the same peculiar position of the arms.

Paleschara ulrichi nov.

Zoarium incrusting or parasitic mostly upon cephalopod shells, covering the entire surface, consisting of relatively large oblong polygonal (mostly irregularly pentagonal or hexagonal) cells (9 to 12 in space of 10 mm) with thin, low walls.

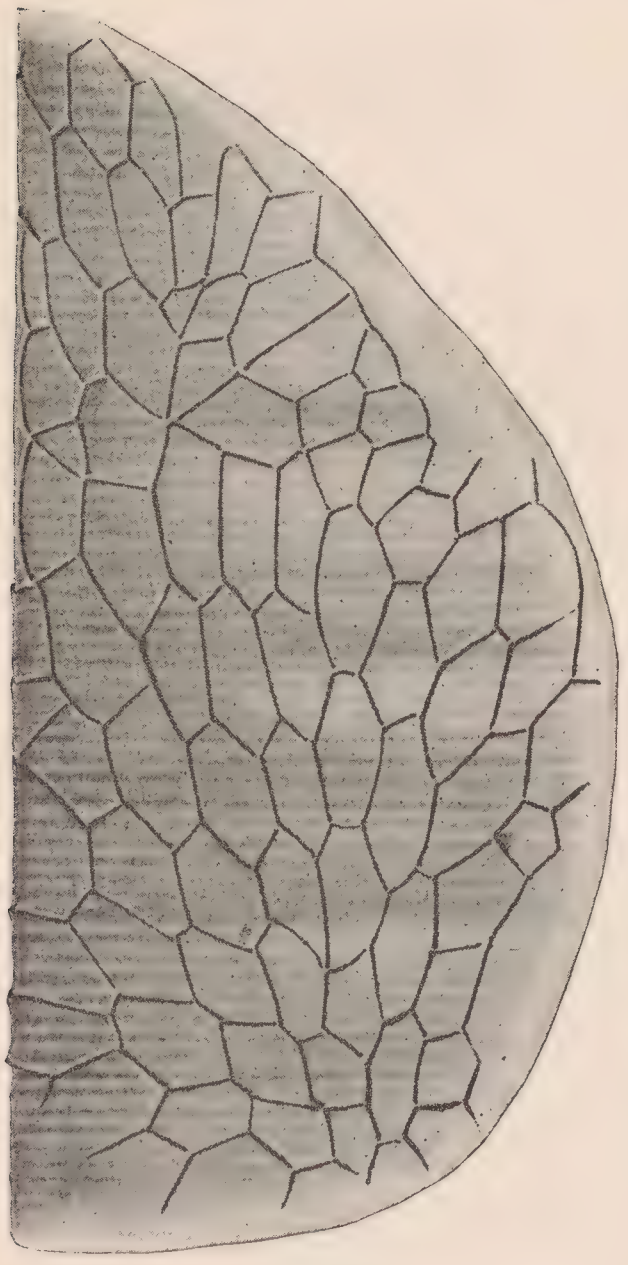

Fig. 29. Paleschara ulrichi nov.

Portion of zoarium, x 10. From Snake Hill beds at Snake hill, Saratoga county, N. Y.

Doctor Ulrich informs me that this species has larger and less regularly arranged cells than are found in its chronologically nearest relatives. Paleschara occurs in the Helderbergian, Niagaran, Richmondian and rarely in the Eden. With this species its range is extended downward to early Trenton.

Position and locality. Snake Hill beds, Snake hill, N. Y.

Remarks. This bryozoan forms a network so delicate that it is just barely visible with the naked eye. The cells are all longer than wide and form a continuous layer on the shell; they radiate from a number of starting points, being apparently composed of different confluent colonies. The corners of the cells are mostly slightly thickened and in some places elevated into distinct tubercles.

Spatiopora sp.

The compressed cephalopod shells in the Utica and Canajoharie shales are very frequently covered by a parasitic bryozoan growth which has in former papers been referred by the present writer to

Sagenella ambigua Walcott. According to information from Doctor Ulrich, these growths represent one or more species of Spatiopora, Sagenella ambigua being one of them. A different incrustation on a cephalopod from the Snake Hill beds is above described as Paleschara ulrichi.

Lingula rectilateralis Emmons

Pl. 4, fig. 1

This species which was originally identified by Hall with L. quadrata Eichwald occurs in good specimens in the Schenectady beds at the Dettbarn quarry at Schenectady and at Rexford Flats. Hall cited the species only from the middle and upper Trenton, but according to Schuchert it ranges from the Trenton into the Lorraine.

Orbiculoidea tenuistriata (Ulrich)

Pl. 4, fig. 2

A single specimen of this species was found at the top of the Frankfort shale in the Frankfort gulf. It has been identified by Doctor Ulrich with his species described in 1878 (Jour. Cin. Soc. Nat. Hist. I, p. 96, pl. 4, fig. 10) from beds of Covington, Ky., that are now referred to the middle part of the Eden group of the Cincinnati region.

Plectambonites sericeus (Sowerby) **typus**

Pl. 4, fig. 3–6

The Snake Hill shale at Snake hill contains a possible but local variety of Pl. sericeus which markedly differs from the currently accepted expression of this extremely variable species in possessing a well-defined mesial fold on the pedicel valve and a corresponding sinus on the brachial valve, as shown in the specimens here reproduced. In other features, notably the general outline and surface sculpture, the specimens do not appear to differ from the general aspect of the species. While we have found this feature neither figured nor described of any of the American representatives of the species, Sowerby's original figures in "Siluric System" exhibit the same outline and relative size as our Snake Hill variety

and clearly also suggest the presence of the mesial fold. Since Sowerby's types were from the Caradoc of Shropshire, they may be of the same age and identical. For that reason we have designated this particular expression of the species as typus; should it be found, however, that the Shropshire and Snake Hill specimens are both local forms, and hence developed independently of each other, those from Snake hill would have to be distinguished by another name, (var. jugata).

Plectambonites centricarinatus nov.

Pl. 4, fig. 7

The Indian Ladder beds have afforded a rather small type of Plectambonites that is distinguished from the other members of the genus by several peculiar features. The most important of these are the presence of a fold on the pedicel and of a mesial sinus on the brachial valve, the sinus in turn bearing a sharp mesial rib; another is the prominent cardinal wrinkles. It has the mesial sinus and fold in common with a variety of P. sericeus from Snake hill. The small Indian Ladder type is no longer referable to P. sericeus as a variety, its general form being relatively longer and the valves flatter. This species, in common with P. sericeus var. asper James, from the Rysedorph Hill conglomerate (title 48, page 18) has the cardinal folds, the tendency to less unequal radiating lines than in the typical P. sericeus and also the acute cardinal angles. Doctor Ulrich has meanwhile pointed out to me that the Rysedorph Hill and James varieties are different. The Indian Ladder form is allied to the Rysedorph Hill variety by the features mentioned and to the P. sericeus from Snake hill in the mesial fold and sinus.

Plectorthis sp. cf. **whitfieldi** (N. H. Winchell)

Pl. 4, fig. 8

A single valve was obtained in the sandy shale of the Snake Hill beds at Snake hill which while agreeing in the surface sculpture with the form here described as Plaesiomys retrorsa, differs greatly in the outline and convexity of the valve. As sug-

gested to me by Doctor Ulrich, it may possibly be the ventral valve of a Plectorthis, like P. whitfieldi (N. H. Winchell). The costae are remarkably sharp, separated by intervals of equal width; they increase twice by interplantation and number forty-six along the margin. Concentric striae are seen in the intervals. The original is an impression on a slab and the marginal parts may not be entirely preserved and hence the outline not as figured.

Plaesiomys retrorsa (Salter)

Pl. 4, fig. 9–12

The Snake Hill beds contain at Snake hill and in other localities large orthid shells, which however in the shales are always badly crushed and flattened. The gritty sandstone and conglomerate beds at Snake hill have afforded some excellently preserved specimens which are here reproduced. These latter show the characteristic features of Salter's P. retrorsa in outline and especially in the retrorsion of the umbo of the pedicel valve and the forward inclination of the cardinal area of the pedicel valve which latter feature distinguishes this species from the closely related P. porcata (see title 5, page 136). The surface sculpture corresponds to that of P. retrorsa as described by Billings (loc. cit.), Meek (title 6, page 93) and Cumings (title 57, page 902). It consists of sharp ribs (about fifty or more along the margin) that increase by intercalation on the brachial valve but are nearly straight on all parts and increase by bifurcation on the pedicel valve. Closely arranged fine concentric lines are seen in the interspaces while the ribs are smooth or but obscurely marked.

The hinge of the brachial valve which hitherto has not been observed, is reproduced in figure 10. It is not essentially different from that of P. loricata figured by Hall and Clarke (title 18, plate 5A, figure 33) and very remarkably like that of Hebertella sinuata figured *ibidem*. A larger valve (plate 4, figure 13) has the characters rather of P. porcata McCoy (see title 5, page 135) than of the closely related retrorsa. Both P. retrorsa and P. porcata occur also in the Trenton limestone at Ottawa; the appearance of these European species in the Snake Hill beds is therefore not a strange feature.

Clitambonites americanus (Whitfield)

Pl. 4, fig. 14–19

The Snake Hill beds furnished several specimens of a Clitambonites that in general aspect resembles Clitambonites diversus (Shaler). Since in the Ohio basin, however, several similar species have been distinguished, we have sent our specimens to Dr August F. Foerste of the Kentucky Geological Survey, who has kindly given us the following brief sketch of the Kentucky species:

In Kentucky, we have three species of Clitambonites. The lowest of these occurs in the Perryville bed. This is characterized chiefly by the great number of rather fine radiating striations; and the relatively greater width of the shell, compared with Clitambonites diversus. In your specimens the striations are coarser than in these Kentucky specimens, and the shell is narrower.

The second horizon occurs in the upper part of the Winchester, Cynthiana, or Catheys horizon (various names for the same set of strata). This species is not well understood. It contains radiating striae about as coarse as yours, but apparently is a smaller, shorter, broader species.

The third horizon is at the base of the Eden, in what I have called the Rogers Gap division of the Eden. To this species I have given the name Clitambonites diversus-rogersensis (title 64, page 323). As far as the coarseness of the radiating striae is concerned, it appears to be about the same as in your specimens. The width of the Kentucky specimens, however, is greater. This is strikingly shown in the case of the brachial valves, in which the ratio of length to width often is as 15 or 16 to 25. In your specimen the dimensions are as 17 to 21.

To me your specimens most resemble Clitambonites americanus Whitfield, an earlier form than any found in Kentucky. In fact, I do not know in what respect your specimens differ from that species.

Of course, you are familiar with Clitambonites diversus. This is one of the larger species, similar to Clitambonites americanus, but with the shell much more strongly convex from beak to anterior margin. Concentric striae are much more constant and conspicuous. The bombiform convexity of the pedicel valve as a rule attracts instant attention. In those specimens of Clitambonites americanus, which I have seen, the antero-posterior curvature is more like that in your specimen.

Clitambonites americanus (Whitfield) was originally described and figured as Hemipronites americanus (title 11, page 243), but referred by Winchell and Schuchert (title

29, page 378) and Schuchert in his Synopsis of the American Fossil Brachiopoda (title 37, page 183) as a synonym to C. diversus. C. americanus was described from the upper Trenton group (Galena horizon) of Wisconsin, and Hall and Clarke (title 18, plate 15A) have figured it from the Trenton of Minnesota. A comparison of our specimens with Whitfield's original description and figures does not appear to bring out any differential characters. The pedicle valve at our disposal appears higher than the original description requires, but it is somewhat laterally compressed and moreover Hall and Clarke (title 18, plate 15A, figures 7 and 8) figure a still higher variety from the Trenton of Minnesota, later separated by Winchell and Schuchert(title 29, page 381) as var. altissima.

Whiteavesia cincta nov.

Pl. 5, fig. 1

Description. Shell small, obliquely ovate, nearly twice as high posteriorly as anteriorly; strongly convex. Hinge line apparently short, extending posteriorly one-third the distance from the beak to the posterior extremity of the shell. Outline passing almost imperceptibly from the hinge line into the oblique well-rounded posterior margin and thence into the more abruptly rounded basal extremity. Basal margin slightly convex, extending obliquely upward. Anterior end apparently short and fairly well rounded. Beak rather prominent, situated between one-fifth and one-sixth of the length of the shell from the anterior extremity; umbonal ridge broad, strongly rounded, very prominent in the upper half, where it is as high as the umbo, then rapidly declining to the posterior extremity. Surface marked by strong, broad, flat concentric folds that appear as elevated bands. On these many fine concentric lines are seen, and very fine raised radiating lines are observable on the cardinal slope. Muscular impressions not seen.

Horizon and locality. Grayish black sandy shale of Snake Hill beds at Snake hill, Saratoga county, N. Y.

Remarks. As Doctor Ulrich has pointed out to me, this species is allied to Whiteavesia cincinnatiensis H. & W., but much smaller and relatively shorter. It also resembles, in our view, W. subcarinata Ulrich, but is less subalate and convex.

The species is apparently rare in the Snake Hill beds, but a single specimen having been collected.

Whiteavesia cumingsi nov.

Pl. 5, fig. 2, 3

Description. Shell of the size of that of the associated W. cincta, but more oblique, thicker or more ventricose, less higher posteriorly (one-third higher than in front) and more elongate. The hinge line is slightly longer, the posterior margin more rounded, the antero-basal margin more distinctly concave, the anterior margin more sharply rounded and the anterior end longer. Beak not as prominent, situated one-fifth of the length of the shell from the anterior extremity; umbonal ridge distinct to posterior margin. Surface lacking the prominent concentric folds of W. cincta, but showing fine concentric lines and a few growth varices. Sometimes also faint postdorsal radii are seen.

Horizon and locality. Common in the olive colored shale at Snake hill, Saratoga county, N. Y.

Remarks. Although a considerable number of specimens were observed on one slab, the specimens are all so much distorted and especially flattened out that they present an entirely different aspect from the normal outline. We have figured also one of these flattened specimens (plate 5, figure 3) to facilitate recognition of the species. Even if the specimen selected as type is a little compressed laterally and therefore too ventricose and elongated, the general outline will not approach that of W. cincta and the characteristic concentric folds of the latter have not been observed in any of the cotypes.

Doctor Ulrich considers this species as being more closely related to W. subcarinata Ulrich (from the lowest Trenton of Minnesota), W. saffordi Ulrich (lower Stones River) and W. cancellata (Walcott). From W. subcarinata our species is distinguished by the oblique outline, the more convex posterior margin and longer anterior end; from W. cancellata by the surface sculpture. W. saffordi is a much older form.

Orthodesma ? subcarinatum nov.

Pl. 5, fig. 5–8

Description. Shells small, elongate, narrow and moderately arcuate, the length from two and one-half to three times the greatest posterior height and from three and one-fourth to three and one-half times the height at the beaks; valves rather strongly convex, culmi-

nating in about the middle of the umbonal ridge. Dorsal and ventral margins distinctly diverging posteriorly, the former straight or but very gently arcuate, the latter with a slight and broad sinus in the middle. Anterior end narrow, produced, the posterior end well rounded and quite convex above the somewhat more abruptly rounded basal part and passing gradually into the hinge line. Beaks not prominent, compressed, about one-fifth of the length of the shell from the anterior extremity; umbonal ridge subcarinate, a very marked feature above and traceable to the postero-basal margin. Mesial sulcus well defined and an obscure broad ridge passing from the beak obliquely forward and downward to the antebasal angle. Surface with irregular undulations and fine intercalated lines. Muscular scars not distinct.

Position and locality. Rather common in a bed of dark gray sandy shale of the Snake Hill beds at Snake hill, Saratoga county, N. Y.

Remarks. Doctor Ulrich writes me regarding this species that it belongs to an early group of Modiolopsidae, combining, with some of its own, the characters of Modiolopsis and Orthodesma, adding: "Its nearest ally is O. subnasutum. Another close ally is the Modiolopsis milleri (Cincinnati), a third M. arguta Ulrich (Black River). Several other species of the group which will some day be distinguished generically are figured on plate 36 of my Minnesota report. The Snake Hill species differs from all in its more sharply defined umbonal ridge. None of the specimens retains its original outline. One (plate 5, figure 5) comes nearest the normal." We have used the latter as type of the species and based our description upon this specimen. The specimen (plate 5, figure 7) is clearly too elongate by lateral compression; there occur specimens which possess not half that relative length and are compressed in antero-posterior direction. It also appears to us that O. subcarinatum possesses a more evenly rounded posterior margin than O. subnasutum and is relatively a little higher posteriorly, and is smaller; but otherwise it is hardly distinguishable from the western Galena form.

Prolobella ? trentonensis (Conrad)

Pl. 5, fig. 4

This species was first described as Avicula trentonensis by Conrad (Jour. Acad. Nat. Sci., 1842, 8:240) from the Trenton limestone and shortly after (title 3, page 161) by Hall

as occurring in "the central and higher portions of the Trenton limestone at Middleville, and in the calcareous layers in the Utica slate at Coldspring, Montgomery county, N. Y." It has been found by us to be not uncommon in the Canajoharie beds at Canajoharie and the old locality of Coldspring is in the same formation not far away on the other (north) side of the Mohawk river.

In the Geology of Minnesota (title 38, page 532), Doctor Ulrich states of this species that it is almost certain that it belongs to his genus Prolobella which he places with the Modiolopsidae, and that it does not belong to the true Aviculidae, "their valves being equal and without the prolonged posterior wing."

Whitella elongata nov.

Pl. 5, fig. 9, 10

Description. Shell of medium size, compressed, subrhomboidal, a little wider posteriorly (by about one-fifth), length about three-fifths greater than posterior width, and shell about six times as long as thick. Anterior margin straight or even slightly concave in upper part, probably subangular at the anterior extremity of the hinge (the extremity not preserved); evenly rounded below, postbasal angle not well seen, apparently also strongly rounded, posterior margin very gently convex or gently straight (but partly seen) gradually merging into the dorsal line. Beaks small and little prominent and probably but little incurved, situated about one-fourth the length of the shell behind the anterior extremity; umbonal ridge very sharp at the beginning, possibly through oblique compression of the shell, becoming obsolete before reaching the postbasal margin. Surface gently convex posteriorly to the ridge and rather flat in front and below it. Surface marked by coarser, distant lines of growth and fine intercalated concentric lines. Escutcheon and hinge not seen, muscular scars but faintly.

Position and locality. Olive gray shaly sandstone of Snake Hill (Trenton) beds at Snake hill, Saratoga county, N. Y.

Doctor Ulrich writes me regarding this species that it belongs in the group of W. compressa Ulrich and W. ohioensis Ulrich, but is more elongate. The former species occurs in the Middle Third of the Trenton shales of Minnesota, the latter in the lower Richmond beds of Ohio. We have obtained but a single specimen of this species, which is obviously rare in our Trenton shales.

Clidophorus foerstei nov.

Pl. 5, fig. 15, 16

Hall (title 3, page 301) cites C. planulatus (Conrad) as occurring besides in the Lorraine beds of northwestern New York, also in the altered slates of Waterford, Saratoga county, N. Y., and figures a specimen from that locality (op. cit. plate 82, figure 9e). We have in our earlier work (Bulletin 42) followed that authority in identifying the Clidophorus from the shales of the Hudson valley with the Lorraine form. The better preserved material since obtained at Snake hill has shown however that there are at least two species of this genus present in the Snake Hill beds, one of rather ventricose form, here described as C. ventricosus, and another that comes near to C. planulatus. Hall's above-cited type from Waterford belongs to this second species. As his own figure shows this species is also more ventricose than the C. planulatus although approaching it closely in general outline. By a careful comparison of the Snake Hill specimens with types of C. planulatus from the Lorraine beds, we have ascertained the following differences: the shell of C. foerstei is less elongate, or relatively higher, in C. planulatus the length being two to two and one-half times greater than the height, and in C. foerstei somewhat less than two times greater; while in the former species the ventral slope is very flat, and the shell much compressed, as expressed in the name; that of C. foerstei is more convex, although not nearly so as in C. ventricosus; the clavicle is decidedly shorter in C. foerstei.

Horizon and locality. Snake Hill beds at Snake hill, Saratoga county, and other localities of that formation in Saratoga and Albany counties.

Clidophorus ventricosus nov.

Pl. 5, fig. 11–14

Description. Shell of medium size for the genus or above; transversely subrhomboidal in outline; subalate; with the height a little more than one-half the length of the shell, anterior end rounded and narrower than the posterior one which is obliquely truncate; the ventral margin is rather strongly convex and the dorsal margin straight posteriorly of the beak and declining obliquely forward in front of the beak. The posterior dorsal and posterior ventral

extremities are both subangular, the former obtusely, the latter acutely so; the anterior extremity is abruptly rounded. Beak small, placed about midlength between the anterior and posterior extremities, umbo not very prominent, shell culminating a little above the center; umbonal ridge broad and traceable to the postventral extremity. Anterior, ventral and posterior slopes evenly rounded, cardinal slope slightly concave. "Clavicular"[1] impression closely in front of the beak, broad but not strong, nearly straight, extending obliquely forward and downward about one-third the distance to the antero-ventral margin. Near the post-dorsal angle are seen (see plate 5, figure 13) small oblique hinge denticles or ribs that are found among Ordovicic forms only in Clidophorus. Muscular impressions not observed. Surface with several coarse varices of growth and fine, very regular concentric lines which are barely visible with the naked eye.

Horizon and locality. Not uncommon in the dark gray to olive colored sandy shale of the Snake Hill beds at Snake hill, Saratoga county, N. Y.

Remarks. This species is readily distinguished from C. planulatus (Conrad) by the much greater convexity of the shells. Doctor Ulrich writes me regarding the same that it shows the beak nearer midlength than it is in any described species; that it is most like an undescribed type from the Southgate division of the Eden at Cincinnati, and that it may be the same as one in the basal part of the Martinsburg shale in Pennsylvania, the specimens of which however are not good enough to decide the matter. The general form is as in Whiteavesia but the characteristic Clidophorus clavicle and the small oblique hinge denticles are present.

Ctenodonta levata (Hall)

Pl. 6, fig. 1

We have cited under this name certain small Ctenodontas from the sandy shale of the Snake Hill beds at Snake hill and elsewhere. Of the specimen figured Doctor Ulrich writes us that he

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[1] This impression is currently termed the *clavicular impression,* but it is obvious that it does not result from the prop or buttress, called *clavicle* in more recent forms, which serves to reinforce the attachment of the resilium or lower ligament. The "clavicle" of Clidophorus is a buttress or lamina which by its position is clearly intended to support the anterior adductor. Its relation to that muscle is well shown in our plate 5, figure 15. The more recent Cucullaea, to cite an analogous case, possesses a like radial buttress for the support of the posterior adductor.

can not distinguish it from specimens from Sacketts Harbor and the writer has taken occasion to compare it with some of Hall's types in the American Museum of Natural History. C. levata is a middle Trenton species; it has been cited from our Utica shale and other higher formations but probably erroneously.

Ctenodonta declivis nov.

Pl. 6, fig. 2, 3

Description. Shell small, acuminate, subovate, height by one-fifth greater than the length, basal margin well rounded, nearly semicircular as in C. obliqua, anterior dorsal margin slightly concave, posterior dorsal margin convex. Beak prominent, situated a little anterior of the center, curved backward; umbonal ridge broad and little prominent, surface sloping gradually forward and more abruptly backward, shell moderately convex, culminating anteriorly of the center. Surface with faint growth lines. Interior characters not observed.

Position and locality. Olive gray, sandy shale of Snake Hill beds, Snake hill.

Remarks. C. declivis is in size and form closely allied to C. obliqua (Hall), a species that is found in all groups of the Cincinnati period. It differs from that species in being higher and having the beak more anteriorly, but may in a revision of the Ctenodontae be found to be but an earlier mutation of that long ranged Western form.

Ctenodonta prosseri nov.

Pl. 6, fig. 4, 5

Description. Shell small, moderately convex, broadly obliquely subtriangular, well rounded in front and broadly rounded below, narrow behind, with fairly large, prominent, incurved beaks, directed posteriorly and situated a little anteriorly (about one-seventh of length) of the middle; umbones carinate behind, the ridge slightly concave in a side view. Hinge not seen.

Position and locality. Snake Hill beds at Snake hill and other places in Saratoga and Albany counties, N. Y.

Remarks. Doctor Ulrich has pointed out to us that this species is closely allied to his species C. scofieldi (title 39, page 593) from the Trenton and Galena shales of Minnesota. Our species

would seem to differ from the western form mainly in the somewhat more elongate form, the less evenly rounded anterior and posterior margins and the more posterior position of the beak.

Ctenodonta radiata nov.

Pl. 6, fig. 6

Description. Shell thin, of medium size, subovate, three-fourths as high as long, anterior margin broadly rounded, posterior oblique and nearly straight or gently convex in the dorsal part and rather sharply rounded below; the ventral margin is but slightly curved. Beaks very little prominent, situated a little more than one-fourth of the entire length behind the anterior extremity. Shell compressed-convex, more convex in posterior half, culminating posteriorly of center in the broadly rounded umbonal ridge. Surface markings consisting of a few growth varices and fine concentric lines, which are crossed on the posterior portion by straight radiating lines. Hinge and muscle scars not observed.

Position and locality. Dark gray to olive, partly sandy shales of Snake Hill beds, Snake hill, Saratoga county, N. Y.

Remarks. This is one of the largest Ctenodontas of the Snake Hill beds; it is readily distinguished from the others by its size, the thinness of its shell and above all the radiating lines. These latter, as several other characteristic features, it has in common with C. calvini Ulrich, a western Richmond (Maquoketa) species. It differs from that younger species in being relatively shorter, narrower behind and higher in front.

Ctenodonta recta nov.

Pl. 6, fig. 7, 8

Description. Shell small, compressed, convex, subtriangular in outline, one-third longer than high; beak rather large but little prominent, incurved, turned slightly backward, situated about midway between the extremities; anterior margin well rounded, posterior more abruptly, and ventral one broadly. Anterior dorsal margin slightly convex, posterior one distinctly concave, impressed so as to form a small lunette. Surface of shell almost uniformly convex, highest subcentrally; with a few well-marked varices of growth and fine concentric lines. Hinge plate and muscular scars not observed.

Position and locality. In the dark sandy shale of the Snake Hill beds at Snake hill and elsewhere.

Remarks. This small type appears to us to be most similar to C. m e d i a l i s Ulrich among the western Trenton forms, with which it has the general outline and the position of the beaks in common. Our species is, however, more elongate and possesses a more convex anterior margin.

Ctenodonta subcuneata nov.

Pl. 6, fig. 9, 10

Description. Shell below medium size, compressed, only about one-eighth longer than high, and about one-eighth as thick as long, acuminate subovate in outline; umbones fairly prominent and beaks incurved, directed distinctly forward and situated between one-third and one-fourth of the length behind the anterior extremity; posterior and anterior ends about equally wide, anterior dorsal margin oblique, slightly concave, posterior dorsal slope slightly convex, postero-basal part well rounded and basal margin broadly rounded. Umbonal ridge broad and distinct only in umbonal region. Surface marked by a few varices of growth and fine concentric lines. Posterior muscle scar faintly seen. Hingle plate not seen.

Position and localities. In dark gray sandy shale of Snake Hill beds, Snake hill, Saratoga county, N. Y.

Remarks. This species is easily distinguished from the associated congeners by its rather high relatively flat shell. According to a note from Doctor Ulrich it is allied to the western Richmond species C. f e c u n d a (Hall). It is relatively higher and less extended posteriorly than the latter.

Allodesma subellipticum Ulrich

Pl. 6, fig. 11

The Canajoharie shale above the falls at Canajoharie has afforded several specimens of a small thin-shelled pelecypod that are much flattened and fail to show any structure. Doctor Ulrich has referred them doubtfully to his A l l o d e s m a s u b e l l i p t i c u m , a species from the Galena shales of Minnesota.

Lyrodesma schucherti nov.

Pl. 6, fig. 12

Description. Shell elongate-ovate, twice as long as high, greatest height a little anterior to middle; anterior part drawn out, posterior one obliquely truncate; shell rather flat, greatest thickness subcen-

tral; cardinal margin nearly straight or slightly declining each way from beak; anterior margin abruptly rounded, basal margin broadly and evenly rounded, posterior basal angle subacute, posterior margin gently convex, passing obliquely upward and forward to the obtusely and obscurely angular posterior cardinal extremity. Beak apparently small, situated fairly midway between the cardinal extremities, umbo not very prominent; umbonal ridge sharply angular. Anterior slope rounded, with a flattening of the nasute anterior extremity; ventral slope evenly rounded; posterior slope concave along the umbonal ridge, abruptly turning into the flat nearly vertical posterior cardinal slope. Surface of anterior and ventral slopes almost smooth, only faint, widely separated growth-lines being visible; the posterior slope bears five sharp radiating ribs and the posterior cardinal slope one or two obscure flat ribs.

Horizon and locality. Very rare (only one specimen found) in dark gray sandy shale of Snake Hill beds at Snake hill, Saratoga county, N. Y.

Remarks. This species is similar in form and size to the shell from the Trenton of Carlisle, Pa., which Hall had referred to the Lorraine species Nuculites poststriata Emmons (title 3, page 151). Ulrich (title 38, page 610) has pointed out that the Trenton Nuculites (now Lyrodesma) poststriata and the Lorraine form are not identical, and has referred the Trenton species with some doubt to his Lyrodesma cannonense. Our species is clearly more elongate than any of these. Doctor Ulrich writes me regarding this species: "Though of the same section of genus, this is not the same species as either of the two Lorraine species that are current under the name L. poststriatum. My Black River L. acuminatum is also one of this section and even nearer. The broader and more common of the two Lorraine species to which the name poststriatum should be restricted, would seem to be a larger shell than this Snake Hill species. The latter is not only smaller but is relatively lower (from beak to ventral margin), relatively wider posteriorly and less strongly convex in the ventral part of its outline."

Hall (op. cit. page 302) cites also Lyrodesma pulchella, a species which typically occurs in the Lorraine beds at Pulaski, as occurring in the "black glazed slates near Waterford" and figures (plate 82, fig. 12c) a small specimen from that locality. Since we now know that the shales about Waterford are all of Trenton age, being partly Canajoharie and partly Snake Hill shales, it is

an *a priori* inference that this small specimen is no longer referable to S. pulchella. A comparison of the figures of the Pulaski type (plate 82, figure 12a) and of the Waterford specimen (12c) shows marked difference in the position of the umbo and the general outline. The latter belongs apparently to one of the small Ctenodontas described from the Snake Hill beds; at any rate it is not identical with the L. schucherti here described.

Solenomya ? insperata nov.

Pl. 6, fig. 13, 14

Description. Shell rather small, very elongate, narrowing anteriorly, its length three times its height, greatest height one-sixth the length from the posterior margin; little convex; the greatest thickness not quite one-fourth the height. Umbones little prominent, situated very posteriorly, one-eighth the length of the shell from the posterior extremity; beaks apparently small and projecting slightly above the hinge. Cardinal and basal margins straight, converging gradually anteriorly; posterior margin slightly concave above and nearly vertical in the lower half; anterior margin evenly rounded. Umbonal ridge distinct and sharp, the anterior slope evenly rounded in the posterior part and becoming rather flat in front; the posterior slope steeply oblique, concave above (apparently with an elongate elliptic area) and flat below. Surface with irregularly spaced concentric folds which are most prominent on the anterior slope and the umbonal ridge and numerous fine concentric raised lines between and upon the folds.

The interior characters have not been seen, no casts of the interior having been obtained.

Position and locality. Rare (but four specimens collected) in the sandy mud shale of the Snake Hill beds at Snake hill, Saratoga county, N. Y.

Remarks. Doctor Ulrich writes me regarding this remarkable pelecypod that its relations seem to be with Solenomya or Clinopistha — both Devonic and Carbonic genera — rather than with any Ordovicic shells known to him, the short end seeming to be the posterior, and he suggests that the species belongs to Solenomya or a new genus. As far as the shale material permits of observation, the beaks are inclined toward the longer end of the shell, corroborating Doctor Ulrich's inference. Since our material does not give any clues to the interior characters and there are no important feat-

ures apparent that would distinguish the form from Solenomya, we have, for the present, left the species with that genus. If this reference is correct, the species is the first representative of the Solenomyidae in the Ordovicic.

Cuneamya acutifrons Ulrich

Pl. 6, fig. 15, 16

In the olive and dark gray sandy shales of the Snake Hill a species occurs which has been identified by Doctor Ulrich with a form from the lower Trenton at Cincinnati, known to him since 1880 and in manuscript since 1886. Doctor Ulrich's description kindly sent to us at our request is as follows:

Description. Shell exceeding medium size for the genus, moderately convex, with the point of greatest convexity near the middle; outline transversely elongate, subovate or subrhomboidal, prowlike

Fig. 30. Cuneamya acutifrons Ulrich.

Holotype. Natural size.

in front, highest in posterior half, narrowing anteriorly to the sharply produced antero-dorsal extremity; umbones large, prominent, the beaks strongly incurved and situated well forward; antero-dorsal edge subparallel with, but appreciably lower than, the hinge line, inflected so as to form a narrow, almost linear, lunule; anterior margin trending backward from the sharp dorsal extremity in a gently sigmoid curve to the ventral side; ventral edge nearly straight, with a barely suggested sinuosity in front of the middle; posterior margin somewhat truncated, moderately oblique, sharply rounded where it joins the dorsal line and more broadly curved in the lower third; dorsal edge nearly straight, the part visible in a side view behind the umbones equaling in length about one-third, the whole to the apices of the beaks rather more than one-half, of the greatest length of the valves; escutcheon very narrow and shallow. Posterior umbonal ridge prominent, rounded, with the slope to the cardinal margin rapid and slightly concave. Two undefined furrows

or sulci are present on the anterior third of the valve; one, very narrow, between the anterior umbonal ridge and the nasute anterior projection; the other running obliquely backwards from the anterior side of the umbones, to the basal margin, where it produces a slight sinuosity. Surface marked with irregular concentric wrinkles, which are generally most prominent over the more gibbous parts of the valve.

Length of best specimen seen, 2.4 inches; greatest height, measuring vertically across the anterior end of the posterior third, 1.15 inches; from a point back of umbones to basal margin, 1 inch; from highest point of umbones to antero-basal portion, 1 inch; length of nasute extension of anterior end, from its extremity to the anterior side of umbones, .38 inch; convexity of one valve, .5 inch.

This species differs from the typical forms of this genus in that the posterior half of the valves is much wider (higher) than the anterior. The generic reference is probably only temporary pending a revision of the shells of this family. Of described species only C. scapha Hall and Whitfield, bears any resemblance. The new species is readily distinguished by its greater width posteriorly, greater convexity, more prominent umbones, smaller lunule, much more acute and prolonged anterior end, less distinct mesial sulcus, and somewhat different surface markings. Closer allies are found among the undescribed species in the Ulrich collection at the United States National Museum.

Formation and locality. This species is rare, and hitherto has been found only in association with Whiteavesia cincinnatiensis (Hall and Whitfield) in a limestone bed exposed in the banks of the Ohio at Covington, Ky. This bed lies near the top of the Bromley shale, a formation corresponding very nearly to the Hermitage formation of middle Tennessee and central Kentucky. Correlating with New York formations its age would be early Trenton.

Holotype. U. S. Nat. Mus. Cat. no. 47314.

Doctor Ulrich observes that the Snake hill specimen is smaller and somewhat shorter, the latter perhaps due to pressure, but otherwise undistinguishable from the Cincinnati specimens.

Saffordia ulrichi nov.

Pl. 6, fig. 17, 18

For a great many years there has been in the State Museum a large fossil shell which had been sent in from one of the "bluestone" quarries at Schenectady[1] and which was considered as a

[1] It is labeled: "Hudson River group, from Schenectada, near the College. From J. L. Coon."

problematicum. On being worked out it proved to be a large lamellibranch and this has been identified by Doctor Ulrich with his genus Saffordia. A second more fragmentary specimen obtained a year ago by the writer in a bluestone quarry between Schenectady and Aqueduct verifies the actual occurrence of the species in the Schenectady sandstone.

Description. Shell large, transversely subovate, the height and length nearly as five is to seven. Dorsal margin nearly straight, very gently convex, anterior margin distinctly concave in upper part and moderately convex in the lower; the ventral and posterior margins form one very strongly and evenly rounded curve. Beaks subterminal, declining forward, strongly incurved, projecting forward nearly as far as the anterior extremity of shell; umbonal ridge very inconspicuous; angular along the dorsal edge. Probably a narrow sulcus on the dorsal slope; ventral and anterior slopes depressed convex. Escutcheon and lunule suggested but not clearly preserved in the type specimen. Surface marked with strong concentric folds that are most prominent in the upper half and become fainter on the umbonal ridge and along the anterior and ventral margins. Internal characters not observed.

Position and locality. In the sandstone of the Schenectady shale at Schenectady.

Remarks. This species differs by its dimensions from all other Saffordias, which are distinguished by their rather small size. In its general outline, the characters of the beak, etc. it most resembles S. ventralis Ulrich, a Richmond species of Minnesota and Wisconsin.

Archinacella orbiculata (Hall)

Pl. 7, fig. 1–6

Hall (title 3, page 306) has described as Carinaropsis orbiculatus a small patelloid gastropod from the "slates of the Hudson River group, near Waterford," which has been obtained by us in the Snake Hill beds of Snake hill and other localities, among them also the contorted shales near Waterford, N. Y. The original description of this species reads as follows:

Suborbicular, apex subcentral, small, slightly inclined; surface finely striated. This species has the form of Orbicula, but the apex is remarkably elevated and no flat valve has been observed.

A comparison of the two type specimens kindly loaned to us by Dr E. O. Hovey, with the description and the original figures (op.

cit. plate 83, figures 8a, b, c) shows that owing to the preservation of the specimens the description and original figures are misleading, and the latter quite incorrect. We have for this reason refigured these types (plate 7, figures 3–6). The apex is broken off in both specimens and the scars of the beaks and the growth lines show that the apex was not subcentral as described, but situated well forward. One specimen (type 8a) is obviously flattened and the other much compressed laterally, as shown by the crest and hence too elongate and high. The surface is nearly smooth and exhibits only obscure finer and a few coarser growth lines. From the type specimens and others from Snake hill we have derived the following description of the species:

Description. Shell small, broadly subovate in outline, length not quite one-fifth greater than width, slightly wider in front than behind, obliquely subconical, apex situated about one-sixth of the length from the anterior margin, apex hardly incurved, apertural margin arched. In profile view moderately concave below the apex and gently convex behind. Surface markings consisting of fine growth lines and some deeper impressed lines near the margin. Length of type (plate 7, figure 3) 7.5 mm; width (too great) 6.2 mm; height 2.0 + mm.

Horizon and locality. Snake Hill shale at Snake hill and other localities in Saratoga and Albany counties.

Remarks. Hall (title 3, page 306) cites his species C. patelliformis, which is typically based on specimens from the Trenton limestone, also from the "semialtered shales near Waterford" without, however, figuring specimens from that locality, his "Hudson River" type (plate 83, figure 7) coming according to Whitfield and Hovey's Type-catalogue (page 50) from Pulaski and being hence a Lorraine type and quite obviously a species different from Archinacella patelliformis. The Waterford specimens differ from A. patelliformis of the Trenton limestone in the profile, the anterior line being much deeper cut in the latter species and the apex more protruding and also situated a little more forward; and in the presence of distinct concentric surface lines in that species. Our specimens of A. orbiculata from the Snake Hill beds are all somewhat laterally compressed, as shown by an irregular carina on the posterior slope, but they show quite clearly that this species was wider in front than in A. patelliformis and that probably it is allied to A. deleta Sardeson as figured by Ulrich and Scofield (1897, plate 61, figures 16–20).

Cyclonema montrealense Billings

Pl. 7, fig. 7

The gritty sandstone bed of the Snake Hill formation at Snake hill has afforded the impression of a small Cyclonema which has the characters of C. montrealense from the Trenton limestone of the island of Montreal. It agrees especially with that species in having the whorls "moderately ventricose, most prominent in the lower half," a rather deep suture, in the character of the spiral lines, of which there are about ten in 4 mm with one or two smaller ones between each pair of the larger lines. The spire is somewhat higher than Billings's description (title 4, page 30) and figure require, but since Ulrich (title 39, page 1059) after an exhaustive study of the western Cyclonemas states that the relative height of the spire is a very unreliable character, and that the form of the whorls is a better character, but that the surface markings have served him best of all in separating the various species, we do not feel warranted in attaching much importance to this difference in the spires.

Cyclonema cushingi nov.

Pl. 7, fig. 8–10

We had repeatedly observed fragments of a gigantic Cyclonema in the Snake Hill beds at Snake hill, but owe the fairly perfect specimen here figured to the collecting spirit of Prof. H. P. Cushing to whom we gladly dedicate this species in recognition of the fact that he does not disdain to be interested in fossils.

The specimens at hand are too badly crushed to allow a description of the species, but since the form is obviously closely allied to C. hageri Billings (1865, page 29), a Trenton form from Montreal island, it seems best to define this new species with the latter by determining its differences from the Canadian relative. The Snake Hill type has in common with the latter the large size and the number of whorls (about four). Also the form of the volutions appears to agree, the upper ones being rather flat or somewhat depressed in the middle, while it is not certain, whether the last volution was as ventricose as in C. hageri, or became concave in the type specimen through being crushed. We believe the latter on account of the presence of the oblique folds and a protruding lower rim in the specimen which indicate a former greater expansion of that volution. The apical angle is apparently less than in the other

species, but the evidence in regard to this character is not conclusive. The surface sculpture exhibits revolving lines which are markedly closer arranged than those of C. hageri, where they are from one to two millimeters apart, while here the larger ones are one millimeter apart, but contain a smaller one between them. C. hageri possesses "strong angular ribs or undulations of growth from half a line (1 mm) to two lines (about 4 mm) apart becoming more prominent with age. The Snake Hill form has on the older volutions closely arranged subequal growth lines, which on the last volution become gathered into elevated bundles of lines, the middlemost of which are thicker and broader than the others. The high folds on the type specimen are largely due to the lateral compression of the shell.

It will be noticed that our species stands in its characters between C. montrealense and C. hageri. The form from the Jacksonburg limestone of New Jersey referred by Weller (title 53, page 186) to C. montrealense, has also its revolving lines farther apart than the Canadian type of that species and more convex volutions, and may represent a fourth expression of the same group. Its revolving lines are of the character of those of C. cushingi.

Hyolithes pinniformis nov.

Pl. 7, fig. 12, 13

Shell small, slightly bent in proximal portion, expanding somewhat rapidly, one side flattened or slightly convex, the other with a blunt median keel. The flat side is longer, projecting with an evenly rounded lobe beyond the aperture, while the keeled side forms a blunt reëntrant angle. The surface is furnished with closely arranged sharp arching transverse striae (growth lines, which are most distinct on the flat side; and with fainter longitudinal lines. Operculum not observed.

Horizon and locality. Canajoharie shale at Canajoharie, N. Y.

Remarks. This species belongs to the group of Hyolithes s. str. in distinction from the subgenus Orthotheca, Novak, according to the character of its aperture. It is distinguished from the other Trenton species of Hyolithes, save H. baconi Whitfield, by its more robust form. The latter species, from the Trenton of Wisconsin is considerably larger and the apertural lobe of the flat side is less projecting.

The type specimen (plate 7, figure 12) measures 13.5 mm in length and 4 mm in width. It shows a distinct, very concave septum in the apical portion. Our specimens are so flattened that their section can not be conclusively determined. It seems to have been elliptical with one side angular.

Orthoceras arcuolineatum nov.

Pl. 8, fig. 1, 2

Slender, small orthoceracone, increasing at the rate of .5 mm of diameter in length of 10 mm. Section elliptic, nearly circular, the minor and major diameters as 7.1 to 7.5 mm. Camerae shallow, nearly four times as wide as deep. Septa closely arranged, about 2 mm apart where the diameter of the conch is 7 mm deep, their depth approximately corresponding to that of the camerae. Sutures arching slightly up on one side. Living chamber not known. Siphuncle centren, small, about one-seventh the diameter of the conch; segments cylindrical, the funnels short and straight. Ornamentation consisting of relatively widely separated (about 2 in 1 mm) sharp raised transverse lines, or ridges, which are intersected by extremely fine longitudinal lines. The transverse lines are strongly bent upward on one of the narrow sides of the conch.

Horizon and locality. Canajoharie shale at Ford Edward, N. Y.

Remarks. This species is based on only the small fragment that is figured here. This shows, however, especially in the ornamentation, characters that distinguish it from other Trenton species known to us. It is apparently, from the character of the siphuncle, a true Orthoceras.

Orthoceras hudsonicum nov.

Pl. 8, fig. 3–10

Small to medium sized, slender, slightly curved cone, with closely arranged septa and subcentral, narrow siphuncle. The cone widens so gradually that in a distance of 50 mm it expands from 5 mm to 10 mm or less (measured in compressed specimen). The septa equal in depth the chambers; they are closely arranged, about 2 mm apart, where the conch is 7 mm wide; the sutures are straight transverse. The siphuncle is centren, wide, about one-third the width of the conch, the funnels apparently short and straight. The living chamber and aperture have not been observed. The nepionic conch possesses only fine longitudinal striae, of somewhat irregular char-

acter, and the mature conch transverse sharp striae, about four to the millimeter; the neanic conch exhibits an intersecting system of both, visible to the naked eye, while on the mature conch still shadowlike traces of the longitudinal lines are visible under the lens.

Formation and locality. In the Canajoharie shale at Alplaus creek, Saratoga county, N. Y., and other places.

Remarks. This species is easily recognized by three characters; its slender, slightly curved shell, the closely arranged septa and the delicate surface sculpture.

The specimens are all more or less crushed, and the septa mostly dissolved and the conch filled with shale. We have, therefore, been unable to satisfy ourselves completely as to the generic determination of the species, and we do not know whether it is a true Orthoceras or not. On account of the relative width of the siphuncle it approaches Baltoceras.

The surface sculpture corresponds exactly to that of Endoceras proteiforme var. tenuitextum, var. tenuistriatum and lineolatum Hall, as described in Palaeontology of New York, volume 1. These Trenton forms do not belong to Endoceras proteiforme but are orthoceratites that need revision. Also the common and often cited "Endoceras. proteiforme" of the Utica slate (title 3, plate 85, figure 1) belongs in the same group which eventually will be referred to, we believe, as Orthoceras tenuitextum Hall. They all have the same rate of growth, the same closely set septa and the same characteristic surface sculpture. We would also have referred the species here described to Hall's species if it were not for the curvature of the conch.

A species identical with our type save its coarse cancellated sculpture, has been described by Walcott (title 9, page 22) as O. oneidense from the Utica shale of Trenton, N. Y.

The most interesting feature of the material from the Alplaus creek is the presence of the embryo shells or protoconchs on the partly pyritized and partly calcified nepionic portions of the conchs (see plate 8, figures 4, 5).

The history of the investigation of the protoconch of the orthoceratites is a very interesting one. Branca considered as the embryonal shell or protoconch the cup-shaped termination of the conch as usually found. Hyatt viewed this chamber as the first chamber and the cicatrix which it generally bears upon its distal surface as the remnant of the protoconch. The latter was figured by

him in the *Genesis of the Arietidae* as a very small, shrunken wart-like appendix, the aspect of which was explained by assuming it to have been composed of conchiolin, which also accounts for its almost invariable absence. In 1893 Clarke (title 20, page 112) announced the discovery of a small fragment of an Orthoceras conch from the Devonic of New York that retains a good-sized calcified protoconch. This minute and interesting specimen was found in the same geological horizon (Styliola-limestone) with protoconchs of Bactrites and distinguished from them by the central position of the siphuncle. The very similar protoconchs and early stages of Bactrites were first described by Clarke in a subsequent paper (title 23, page 37) and more fully in the first part of the Memoir on the Naples Fauna (page 122). Hyatt in his *Phylogeny of an Acquired Characteristic* assumes regarding the protoconch of that Orthoceras the stand that this " form certainly has the characters of an Orthoceras, but the protoconch is large and like that of the Ammonoidea. The shell may be transitional from Orthoceras to Bactrites, but it is probably not a typical form of Orthoceras." This view which gives the small fragment from the Styliola limestone still greater phylogenetic interest, was later (op. cit., page 130) concurred in by Clarke, who considers it " conceivable that such differences as are here indicated by the young [of Orthoceras and Bactrites] may be totally extinguished in the later growth stages so that the mature form of the species in question may be before us, though present knowledge does not enable us to recognize it." Even if the unique small shell described by Clarke represents but a transitional form, it demonstrates that there must exist true Orthoceras with like large calcareous initial chambers. Indeed such were found not long after by Pocta.

In 1902 Pocta (title 50) published a note on the initial chamber of Orthoceras, his observations being based on the sections of diabas tuffa of the band e_1, of the Bohemian Upper Siluric. These sections showed clearly the presence of a baglike protoconch in both longiconic and breviconic orthoceratites, the species of which, however, could not be determined. Pocta obtained the following conclusions:

1 The genus Orthoceras possessed a calcareous initial chamber.

2 The form of the same was baglike, somewhat contracted downward, but always of greater width than the first air chamber.

3 This protoconch exists only in juvenile stages, later it is absent, and its traces in mature individuals are extremely rare (Clarke).

4 The first siphonal funnel was collarlike reflexed and thus formed the scar (Barrande's "cicatrix"). This first siphonal funnel has as a rule a different shape from that of the other funnels of the conch.

Our material consisted only of about half a dozen protoconchs which, however, were large enough (1.6 mm wide) to be broken out and in two instances made into thin sections. Both the exterior view and the sections verify Pocta's observations as to the width of the protoconch being greater than the first camera and the reflexed character of the first funnel. It will be noticed that in O. hudsonicum the volume of the protoconch corresponds approximately to that of the first camera.

This is the first observation of the protoconch of an Orthoceras in the Lower Siluric, Doctor Clarke's specimen coming from the Devonic and Professor Pocta's from the Upper Siluric. The different character of the nepionic conch of Endoceras has already been described by Holm in 1885 (Pal. Abh. von Dames and Kayser, volume 3, and Geol. Fören. i Stockholm Förhandl. 1896, volume 18). The protoconchs of orthoceratites are by no means rare in the Utica shale, for we had already obtained a large series of pyritized specimens at Dolgeville some fifteen years ago. These, however, were lost in transportation and the bed has become inaccessible by the building of a dam. The Dolgeville material was the same or a very closely related species.

Oncoceras (?) sp.

Pl. 8, fig. 12

A completely flattened specimen from the Canajoharie shale at North Albany. Its condition does not allow either a definite generic determination or a sufficient specific diagnosis. The living chamber was short and the apertural portion somewhat contracted; the aperture apparently regular and circular. The septa are seen only faintly, they were closely arranged and arched on both the ventral and dorsal sides. The siphuncle is very indistinct, apparently with straight segments. The form seems to be distinct from the other Trenton species of Oncoceras but would not warrant being named.

Conularia trentonensis var. multicosta nov.

Both the Schenectady and the Snake Hill beds have furnished specimens of a Conularia which possesses the characteristic apical angle (18°–20°) and sculpture of C. trentonensis, i. e. a system of transverse ridges crossed by closely set longitudinal bars,

with the difference, however, that the sculpture is much finer in the shale variety, the ridges and bars being just about twice as closely set and correspondingly lower than in the trentonensis (15 to 17 ridges in 5 mm as against 6 to 9 in C. trentonensis). This difference having been found to be constant in all specimens observed in the shale (Snake Hill beds at Watervliet and the Schenectady beds at Schenectady and Schoharie Junction), it becomes necessary to recognize it as of at least varietal importance. We therefore propose to distinguish this form as var. multicosta.

It represents the other extreme of variation to the type described by Emmons (Amer. Geology, 1:208) as C. hudsonia from the Lorraine beds at Lorraine, N. Y., which latter form exhibits the trentonensis-sculpture about twice as coarse as the Trenton type.

A fragment of a specimen from Watervliet retains part of the apertural lobe. The sculpture on this consists of the transverse ridges which are much more crowded than on the lateral faces of the shell and sharply bent forward in the middle.

Eoharpes ottawensis (Billings)

Pl. 9, fig. 1

A single specimen found in a loose slab of Snake Hill shale on Snake hill, represents thus far this Canadian species in our State. The species was first described from the Trenton limestone of Ottawa (Can. Pal. Fossils, 1865, 1:182); later a doublure of a head shield from the Galena of Wykoff, Minnesota, was also referred with doubt to this species by Doctor Clarke (title 32, page 757). Weller (title 53, page 191) has also recognized the species in the fauna from the Jacksonburg limestone at Jacksonburg, N. J., and Bassler (title 62, page 111) lists it from the Liberty Hall limestone (Chazy) of Virginia.

Our specimen has been slightly laterally compressed and therefore appears somewhat more slender than the type, but otherwise it fully agrees with the original drawing of the latter. It also distinctly exhibits the surface punctae characteristic of Billings's species.

Isotelus gigas DeKay

Pl. 10, fig. 1

We figure here a fairly well-preserved specimen of this widely known trilobite which, labeled as coming from the bluestone quarries at Rexford Flats, N. Y., has been in the State Museum

for some time. It is the only example of this species known to us from the Schenectady beds and appears to agree in all essential characters with the Trenton type. The fact that it is narrower and higher is due to lateral compression.

Proëtus undulostriatus (Hall)

Pl. 9, fig. 2, 3

Olenus undulostriatus Hall. Pal. N. Y., 1847, 1:258, pl. 67, fig. 3a, b.

Cf. Proëtus parviusculus Hall. 13th An. Rept. N. Y. State Mus. Nat. Hist., 1860, p. 120.

Elliptocephala undulostriata S. A. Miller. North Amer. Geol. & Pal., 1889, p. 546.

Bathyurus sp. Whitfield & Hovey. Bul. Amer. Mus. Nat. Hist., pt. 1, 1898, 11:70, 71.

Proëtus parviusculus Ruedemann. N. Y. State Mus. Bul. 42, 1901, p. 536.

Cyphaspis hudsonica Ruedemann. N. Y. State Mus. Bul. 49, 1901, p. 64, pl. 4, figs. 8, 9.

The writer described in 1901 several small cranidia from the black limestone pebbles from the Rysedorph Hill conglomerate which are especially characterized by a fine system of transverse or concentric sculpture lines, as Cyphaspis matutina, and another cranidium of broader habit from the supposed Upper Utica shale of Green island as C. hudsonica. Collecting in the Snake Hill beds at Snake hill furnished a few years ago a cranidium (plate 9, figure 3) which not only exhibits the identical characteristic sculpture of C. matutina but also resembles it in all other features with the exception that it is a little broader and the frontal limb distinctly narrower. In the latter features it fully agrees with the C. hudsonica which comes from beds which we now know to be identical with the Snake Hill beds. This latter specimen proves on reinvestigation to be exfoliated, for which reason the surface sculpture is not observable while the glabellar furrows are more distinct.

Hall had in 1847 described and figured as Olenus undulostriatus from the "Hudson River group" of Snake hill, the mold of a carapace and part of the thorax of a trilobite which since that author had referred in his early work a considerable number of Lower Cambric fossils to the "Hudson River group," had also been placed by catalogers in the Cambric, or rather since the original description is very brief and the figure quite unsatisfactory, it has

been left out of consideration in discussions of the Lower Siluric faunas. Hall's type, which was kindly loaned to us by Dr E. O. Hovey, proved, from gutta-percha squeezes, to be specifically identical with the specimens in our collection from Snake hill and also with the other specimen formerly described by us as Cyphaspis hudsonica. We have here (plate 9, figure 2) introduced a new figure of the original of Olenus undulostriatus from a gutta-percha squeeze.

While Hall referred his species to Olenus and Miller placed the same under Elliptocephala, Whitfield and Hovey in the catalog of palaeontologic types of the American Museum of Natural History, have cited that type as Bathyurus sp.

We had placed the cranidia from the Rysedorph Hill conglomerate and of Green island with Cyphaspis on account of the form of the glabella and the large basal lobe. From inspection of the whole carapace and the thorax we have however become convinced that those species should be more properly referred to Proëtus, the isolation of the basal lobe being too indistinct for Cyphaspis and the carapace relatively too broad and the glabella not prominent enough. On the other hand, while we recognize the similarity of the carapace of P. undulostriatus to that of Bathyurus in its former generalized conception, we doubt that this genus, as characterized by its genotype, B. extans (Hall), could be made to receive forms like the present with a distinct thick anterior margin and a much broadened base of the glabella through a more or less prominent basal lobe. All these are features characteristic of Proëtus and are becoming still more emphasized in Cyphaspis, but absent in Bathyurus.

Proëtus matutinus Ruedemann from the Rysedorph Hill conglomerate is obviously a closely related older form, the black pebbles being probably of Black River and the Snake Hill beds of Trenton age. It is mainly distinguished by the broader frontal limb of the cranidium. The glabella is also distinctly more convex, but this may be due to the preservation in limestone, the shale fossils always being more or less flattened. The fine anastomosing sculpture lines are identical in P. undulostriatus and matutinus.

In New York State Museum Bulletin 42, 1901, page 536, the present writer has cited from the "Middle Trenton shales," exposed at the Brothers quarry at South Troy, Proëtus parviusculus Hall, from a cranidium collected by him at that locality.

The same is now packed away and at present not accessible, but the writer feels sure that this cranidium also belongs to P. undulostriatus from his recollection of the minute fossil and from the fact that P. parviusculus is clearly a very close relative of P. undulostriatus. The small specimen from Troy was exfoliated and therefore failed to show the striae.

P. parviusculus in size and outline of carapace and glabella would appear to be difficult of differentiation from the Snake Hill species. The fact that its surface is described as "smooth, or very finely granulose" would seem to furnish a distinctive character.

Beecher (1895, p. 174) states, however, regarding the surface sculpture of this species: "In the original description of this species, no mention was made of fine undulating striae ornamenting the entire dorsal surface of the test, nor of the basal lobes of the glabella. Both these features are present in the type specimen, which is from Cincinnati, Ohio, as well as in all the specimens from the Utica slate near Rome, New York."

If it were not for the fact that the cheeks and glabella of the types of P. undulostriatus and P. hudsonicus are relatively broader than those figured of P. parviusculus and the genal spines diverging instead of being subparallel, we should not hesitate to consider parviusculus a synonym of the older term. Since these differential characters in the scant material at our disposal — and especially in the type specimen — may be due to longitudinal compression, it is possible that later collections will demonstrate the identity of the Cincinnati and Snake Hill forms. At any rate, if different, they are very closely related.

The species here described presents in its outline great similarity to Proëtus latimarginatus Weller from the Jacksonburg limestone of New Jersey. The latter type is however described as possessing a finely granulose surface.

Acidaspis crossota (Locke)

Pl. 9, figs. 4, 5

A small Acidaspis from the Indian Ladder beds, represented by a cranidium and several fine cheeks, has been identified by Doctor Ulrich with Acidaspis crossota Locke, a form hitherto known only from the Cincinnati group of the neighborhood of Cincinnati. It is recorded by Nickles as ranging through the Eden ("Utica") shale of Cincinnati.

Calymmene senaria Conrad

Pl. 9, fig. 6–10

The Canajoharie shale in the Mohawk valley often contains as one of its more frequent fossils quite large specimens of Calymmene senaria. These, as first noticed by Doctor Ulrich, bear upon the occipital ring a larger median tubercle not found in the common Trenton or Utica specimens and obviously representing a varietal character. It is distinctly seen on the specimen reproduced in figure 6, but the largest specimen here figured also possessed a larger, though flatter elevation upon the middle of the occipital ring.

The material of this species from the Canajoharie shale proved especially interesting through the fact that the fine black shale has retained the earlier growth stages. Among the latter was found a well-preserved specimen of a protaspis (see plate 9, figure 7), which to our knowledge has not as yet been observed of this genus. The very prominent marginal eyes and the fine segments of the glabella, the middlemost of which is largest, are the most striking features of this trilobite embryo. We also figure a nepionic and early neanic stage to illustrate the changes in the glabella, leading to the suppression of the embryonic annulations. The protaspis here figured is practically identical with that referred to Proëtus parviusculus by Beecher,[1] and the question arises whether it should not also be referred to that genus. Since our protaspis is fairly well connected with the adult Calymmene by the neanic stages here figured, and Proëtus parviusculus has not been found associated with it in the Canajoharie beds; we feel certain of its ontogenetic connection with the common Calymmene senaria of that formation.

Ulrichia ? bivertex Ulrich

Pl. 9, fig. 11, 12

Associated with Primitiella unicornis the Canajoharie shale at Canajoharie contains in considerable numbers an ostracod of rather striking appearance through two prominent tubercles near the dorsal margin. This species was first published by Doctor Ulrich as Leperditia bivertex (title 8, page 10) from the neighborhood of Cincinnati and is now referred by him to

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[1] The larval stages of Trilobites. Amer. Geologist 16, pl. 9, figs. 5, 6.

the genus Ulrichia with some doubt. It is usually as at Canajoharie associated with Primitiella unicornis in the lower Trenton and in the "Utica" of Cincinnati.

Eurychilina subradiata Ulrich

Pl. 9, fig. 16

A specimen of this species which has been recorded by Doctor Ulrich (Jour. Cin. Soc. Nat. Hist., 1890, 13:126; Geology of Minnesota, part 2, 1897, 3:661) from "Birdseye and Lower Trenton" of the Middle West (Minnesota-Tennessee) was also collected in the shaly basal Trenton of the Canajoharie section. The New York type is according to Doctor Ulrich a close derivative of the western form which is there a good Black River species.

Primitiella unicornis Ulrich var.

Pl. 9, fig. 13, 14

This minute ostracod was first made known by Doctor Ulrich in 1879 (title 8, page 10, plate 7, figure 4), and later more fully described and illustrated in the Geology of Minnesota (title 38, page 649). It is stated by its author to occur abundantly in the lower part of the Cincinnati group about Cincinnati and also recorded by the same authority from near the base of the "Hudson River group" in Minnesota and in a slightly different variety from Manitoba (title 15, page 50). Professor Nickles (title 49, page 71) records it from his lowest division of the "Utica" at Cincinnati. Doctor Ulrich has denoted the Canajoharie form as corresponding to the "basal Trenton variety." This variety appears to us to be distinct from the type of the species in being more elongate and thicker in the posterior part. The spine is somewhat larger and the slight node in the dorsal depression larger.

It has been observed by us in this State only in the lower part of the Canajoharie shale.

Ceratopsis chambersi (Miller) var.

Pl. 9, fig. 15

The Indian Ladder beds at the Indian Ladder have furnished us an ostracod which like many of its associated forms has before been only known from the Cincinnati region, whence it was first described

by S. A. Miller (Cincinnati Quar. Jour. Sci., 1874, 1:234) and from the West. It has been more fully made known by Doctor Ulrich (Jour. Cinc. Soc. Nat. Hist., 1890, 13:112; Geology of Minnesota, part 2, 1897, 3:676).

This species which in several varieties occurs in the Trenton, Cincinnati and Richmond formations, is characterized by the spine-like form of the postdorsal process. Our specimen represents a variety that may be peculiar of the Indian Ladder beds. One of its features is the separate development of the upper end of the post-medium ridge as a small rounded node. Doctor Ulrich (op. cit. page 676) figures a similar specimen and remarks that it is the only case of the kind seen and may be abnormal.

Pollicipes siluricus Ruedemann

In New York State Museum Bulletin 42 (1901, page 518) the writer described as P o l l i c i p e s s i l u r i c u s a crustacean from the Snake Hill beds of Green island, N. Y., announcing it as the first lepadid or "goose barnacle" yet known from the Paleozoic. He has since learned that Dr W. S. Aurivillius had before (Bihang Svenska Vet.-Akad. Handl., 28, Afd. 4, No. 3, 1892) made known two species of Pollicipes and seven of Scalpellum from the Upper Siluric of Sweden, thus leaving to the Snake Hill barnacles only the distinction of being the first Lower Siluric or Ordovicic ones known.

In a note on the geologic distribution of Pollicipes and Scalpellum by Doctor Bather (title 46, page 112) this author suggests that my figures of P o l l i c i p e s s i l u r i c u s belong to more than one species and that therefore a holotype of P. s i l u r i c u s should be selected and the species separated. Although Aurivillius's species are based on differences in form of plates etc. of no greater amount than those in our material, we do not deem it safe at present to distinguish more than one species for the reason that the plates have suffered distortion in the much contorted shales, and we therefore restrict ourselves here to designating the original of figure 17, plate 2, *op. cit.* as the holotype.

Technophorus cancellatus Ruedemann

Pl. 9, fig. 17, 18

This peculiar fossil has been described by the writer (title 47, page 572) from the shale of Green island, Albany county, N. Y., then referred to the Utica, where it occurs in the same association as

found on Snake hill. We figure here two specimens showing additional features. Our species is a very close ally of T. punctostriatus Ulrich (title 22, page 685) from the Cincinnati group, with which it has above all the striking surface ornamentation in common. Doctor Ulrich writes me that T. cancellatus has a proportionally greater length and more prominent rostrum. Since T. punctostriatus occurs in the middle beds of the Cincinnati group it is also considerably younger than the Snake Hill species.

Miller considered his genus Technophorus as belonging to the lamellibranchs and Ulrich (title 38, page 612) retained the genus in that class, pointing out, however, that in the surface ornamentation and the character of the beaks as they appear in casts of the interior, the genus differs from all known Paleozoic representatives of the class, with the possible exception of Ischyrina Billings.

The markings are such as to suggest the crustacean nature of Technophorus and the beaks form a single pyramidal prominence instead of two separate points as in lamellibranchs. The Snake Hill species seems to be distinguished from the others by an especially prominent beak (plate 9, figure 18).

Doctor Clarke in describing a very similar fossil from the Oneonta sandstone (New York State Museum Memoir 6, part 2, 1904, page 406) has stated that he is "more inclined to regard these clavicle-bearing genera (Technophorus and Ischyrina) as bodies like Ribeiria and Ribeirella which Schubert and Waagen have shown to be apodiform crustaceans (Jahrb. der k. k. geol. Reichsanst. 1903, 53:337), adding that "it is doubtless true that Technophorus is a ribeirioid crustacean." Doctor Ulrich now also considers these genera as crustaceans.

EXPLANATION OF PLATES

Plate 1

Spnenophycus latifolius (Hall)

Page 73

Fig. 1 Example resembling Hall's type.
Fig. 2 Lobate thallus, showing short conical marginal cavities.
Fig. 3 A large fragment of thallus, showing at the right lower margin the cavities, giving it a lobate appearance.
Fig. 4 A thallus showing very distinctly the conical marginal cavities.
Fig. 5 Large thallus with radiating impressions and cavities.
Fig. 6 Small thallus showing perfect margin with cavities.
Fig. 7 Thallus with complete outline.
Fig. 8 Thallus with broad, partly overlapping lobes.
Fig. 9 Thallus showing parallel, distally diverging lines and a medial row of double pits, doubtfully referred here.
Fig. 10 Thallus with extremely lobate outline. The specimens, figures 4–6, 8–10, only doubtfully referable to this species.

Horizon and locality. Schenectady beds. Aqueduct near Schenectady, N. Y.
All figures are natural size. The originals are in the State Museum.

G. S. Barkentin del.

Plate 2

Sphenophycus latifolius (Hall)

Page 73

Fig. 1–4 Specimens showing the more common aspects of the fossil Natural size. Figure 1 shows also a bandlike breaking up of the test; figure 2, the most frequent and typical aspect of the bodies; figure 3, showing a breaking of the stem into longitudinal shreds at *b;* figure 4, specimen with long, thin pedicel.

Fig. 5 Specimen in which the upper test has become exfoliated, revealing a flattened interior space.

Fig. 6 Specimen in which the wrinkling suggests the originally inflated condition of the bulb; it also shows a bandlike shred of the pedicel.

Fig. 7, 8 Specimens remarkable for the extreme inflation of the bulb. Figure 8 shows at *b* a cylindrical section of the pedicel.

Fig. 9 Specimen showing a marginal, distal wrinkle and slight extension resulting from the flattened apex of the bulb, folded upon itself.

Fig. 10 Specimen also distinctly showing the apical wrinkle or fold, and a slight inflation in the pedicel.

Fig. 11 Finely preserved specimen showing the flattened oval space at the top of the bulb and a bulbous swelling of the pedicel (at *a*).

Fig. 12 Specimen showing finely the apical flattening of the bulb with a central, probably accidental perforation.

Fig. 13 Fragment of fronds of Sphenophycus latifolius, showing their spiral arrangement and the stems of several specimens of bulbs.

Fig. 14 Circular, originally probably spherical body found associated with the bulbs.

Figure 9–12 are x 2; the others natural size.

Horizon and locality. Schenectady beds. Aqueduct near Schenectady, N. Y.

Dictyonema arbuscula (Ulrich)

Page 77

Fig. 15 Specimen in natural size.

Horizon and locality. Indian Ladder beds. Indian Ladder, Albany county, N. Y.

Dictyonema multiramosum nov.

Page 78

Fig. 16 Holotype. Natural size.

Horizon and locality. Schenectady beds. Rotterdam Junction, Schenectady county, N. Y.

Diplograptus peosta Hall

Fig. 17 Specimen in natural size from Indian Ladder beds. Indian Ladder, Albany county, N. Y.

Diplograptus (Mesograptus) mohawkensis nov.

Page 80

Fig. 18 Typical (holotype) specimen from Canajoharie shale, Swartztown creek near Amsterdam, N. Y. Natural size.

Fig. 19 Specimen (paratype) from Canajoharie shale at the Carlsbad Spring near Saratoga Springs, N. Y.

Diplograptus (Amplexograptus) macer nov.

Page 82

Fig 20, 21 Cotypes. Natural size. Uppermost Canajoharie shale at Minaville, Montgomery county, N. Y.

The originals are in the New York State Museum.

G. S. Barkentin del.

Plate 3

Taeniaster schohariae nov.

Page 88

Fig. 1 Holotype. x 5. The middle arm exhibits the ventral view.
Upper Schenectady beds near Schoharie Junction, Schoharie county, N. Y.

Edrioaster saratogensis nov.

Page 86

Fig. 2 Holotype. x 5. Specimen showing the five ambulacral rays, oval aperture, subambulacral plates (at *a*) and the inner thecal plates of the interambulacra.

Fig. 3 Paratype. x 5. Specimen showing three of the oral plates, distinctly the suture-lines of one interambulacrum and what is apparently an anal pyramid (at *a*).

Fig. 4 Paratype. x 5. A badly crushed specimen which however well exhibits the extremital part of an ambulacral ray at *b;* and the subambulacral pavement of plates at *a*.
Snake Hill beds at Snake hill, Saratoga county, N. Y.

Heterocrinus ? gracilis Hall

Page 86

Fig. 5 A specimen from the original locality of the species. Natural size.
Snake Hill beds at Snake hill, Saratoga county, N. Y.

Carabocrinus cf. **radiatus** Billings

Page 86

Fig. 6 A calyx plate. Natural size.
Snake Hill beds at Snake hill, Saratoga county, N. Y.
All figures are taken from squeezes. The originals are in the New York State Museum.

G. S. Barkentin del.

Plate 4

4

Lingula rectilateralis Emmons

Page 91

Fig. 1 Specimen figured in natural size.
Schenectady beds. Dettbarn quarry, Schenectady, N. Y.

Orbiculoidea tenuistriata Ulrich

Page 91

Fig. 2 Pedicle valve. x 4.
Top of Frankfort shale, Frankfort gulf, N. Y.

Plectambonites sericeus (typus) Sowerby

Page 91

Fig. 3, 4 Two pedicle valves, showing the mesial fold. Figure 7 x 2; Figure 8 x 3.
Fig. 5 Brachial valve. x 2. From squeeze.
Fig. 6 Interior of brachial valve. x 2. From squeeze.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Plectambonites centricarinatus nov.

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Fig. 7 Holotype. Pedicle valve. x 4.
Indian Ladder beds. Indian Ladder, Albany county, N. Y.

Plectorthis sp. cf. **whitfieldi** (N. H. Winchell)

Page 92

Fig. 8 Brachial valve. Natural size. From squeeze.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Plaesiomys retrorsa (Salter)

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Fig. 9 Brachial valve. Natural size. From squeeze.
Fig. 10 Cardinal portion of brachial valve. x 2. From squeeze.
Fig. 11 Pedicle valve. Natural size.
Fig. 12 Enlargement (x 5) of surface.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Plaesiomys cf. **porcata** McCoy

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Fig. 13 Pedicle valve. Natural size. From squeeze.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Clitambonites americanus (Whitfield)

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Fig. 14, 15 Two views of brachial valves. Natural size.
Fig. 16–19 Views of the pedicle valve. Natural size.
Snake Hill beds. Snake hill, Saratoga county, N. Y.
All originals are in the New York State Museum.

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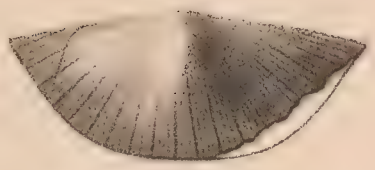

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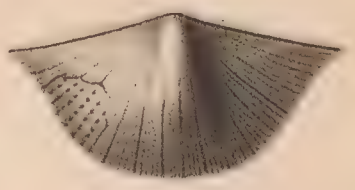

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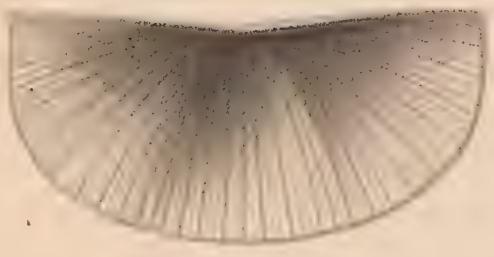

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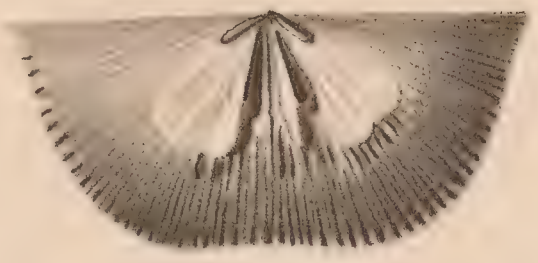

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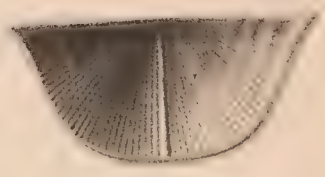

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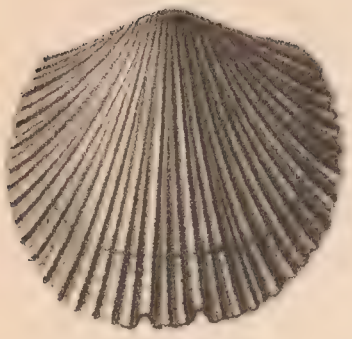

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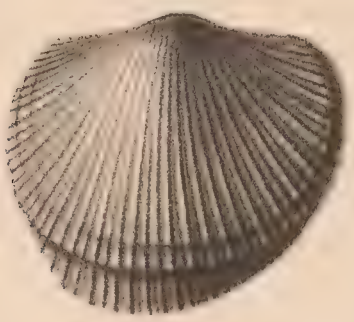

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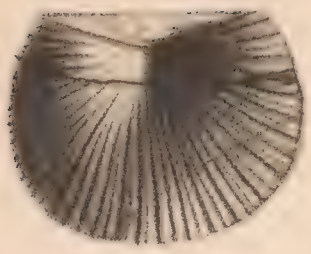

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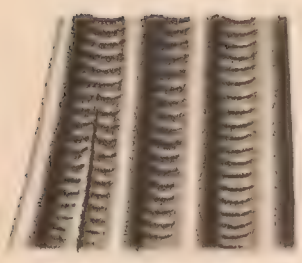

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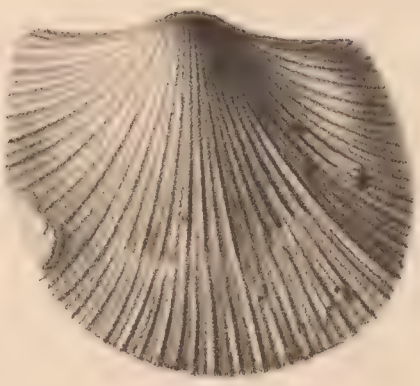

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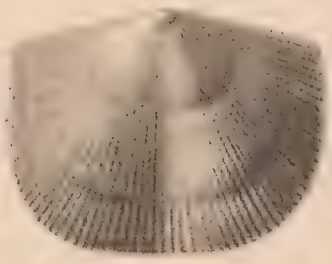

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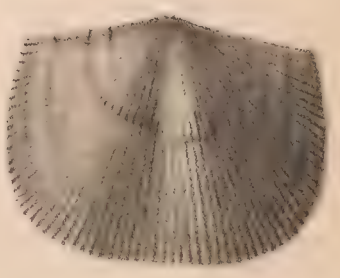

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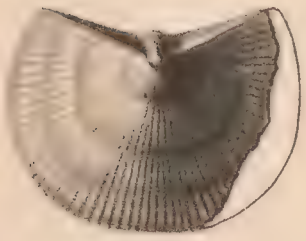

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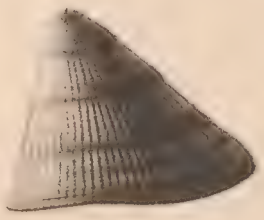

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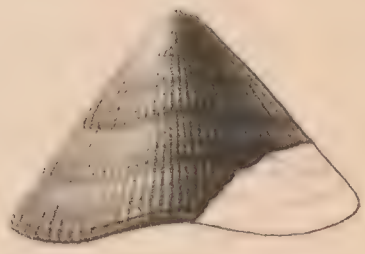

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Plate 5

Whiteavesia cincta nov.

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Fig. 1 Holotype. x 3.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Whiteavesia cumingsi nov.

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Fig. 2 Specimen that is probably but little distorted. Holotype. x 2.
Fig. 3 Another specimen, showing a frequent expression of the form. Paratype. x 2.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Prolobella ? trentonensis (Conrad)

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Fig. 4 Specimen. x 2.
Canajoharie shale. Canajoharie, Montgomery county, N. Y.

Orthodesma ? subcarinatum nov.

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Fig. 5, 6, 7 Specimens (cotypes) showing the more frequent and apparently least distorted appearances of the species in the folded shales of Snake hill. x 1.5.
Fig. 8 Dorsal view. x 1.5.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Whitella elongata nov.

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Fig. 9 Holotype. Natural size.
Fig. 10 Dorsal view of same.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Clidophorus ventricosus nov.

Page 99

Fig. 11, 12 Lateral and anterior views of the holotype. x 3.
Fig. 13 A more elongate specimen showing hinge-denticles. x 1.5.
Fig. 14 A specimen with very distinct clavicle. x 3.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Clidophorus foerstei nov.

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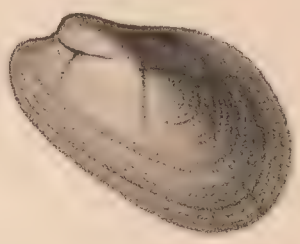
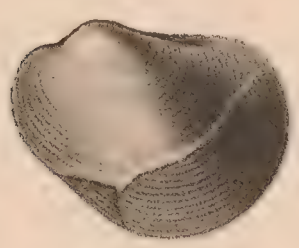
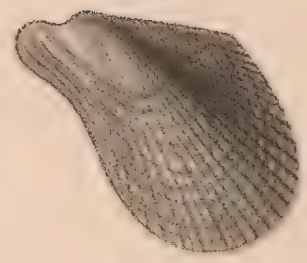
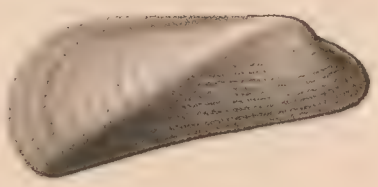
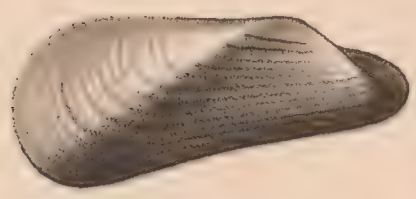
Fig. 15, 16 Lateral and ventral views of the holotype. x 3.
Snake Hill beds. Snake hill, Saratoga county, N. Y.
All originals are in the New York State Museum.

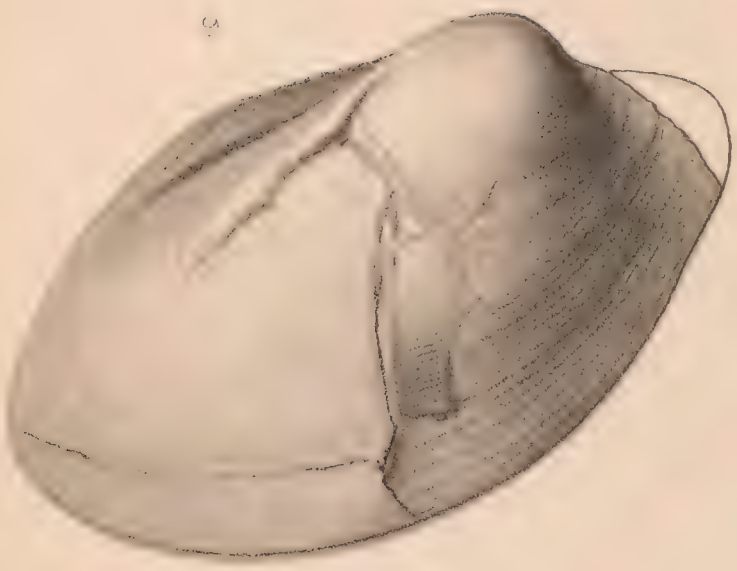


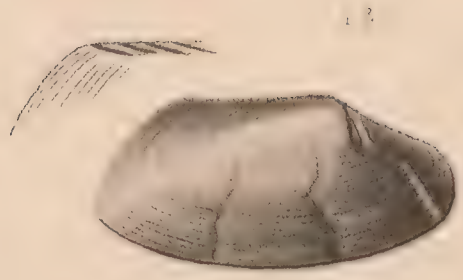












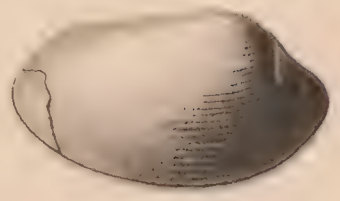


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Plate 6

Ctenodonta levata (Hall)

Page 100

Fig. 1 Right valve. x 2.

Snake Hill beds. Snake hill, Saratoga county, N. Y.

Ctenodonta declivis nov.

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Fig. 2, 3 Lateral and posterior view of holotype. x 2.

Snake Hill beds. Snake hill, Saratoga county, N. Y.

Ctenodonta prosseri nov.

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Fig. 4, 5 Lateral and posterior views. x 4.

Snake Hill beds. Snake hill, Saratoga county, N. Y.

Ctenodonta radiata nov.

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Fig. 6 Lateral view of holotype. Natural size.

Snake Hill beds. Snake hill, Saratoga county, N. Y.

Ctenodonta recta nov.

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Fig. 7, 8 Lateral and posterior views of holotype. x 3.

Snake Hill beds. Snake hill, Saratoga county, N. Y.

Ctenodonta subcuneata nov.

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Fig. 9, 10 Lateral and posterior views of holotype. x 1.5.

Snake Hill beds. Snake hill, Saratoga county, N. Y.

Allodesma cf. **subellipticum** Ulrich

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Fig. 11 Specimen. x 2.

Canajoharie shale. Canajoharie, Montgomery county, N. Y.

Lyrodesma schucherti nov.

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Fig. 12 Holotype. x 2.

Snake Hill beds. Snake hill, Saratoga county, N. Y.

Solenomya ? insperata nov.

Page 105

Fig. 13, 14 Two specimens (cotypes) showing the common expression of the form. x 1.5.

Snake Hill beds. Snake hill, Saratoga county, N. Y.

Cuneamya acutifrons Ulrich

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Fig. 15 Anterior portion of specimen. Natural size.

Fig. 16 Surface sculpture. x 8.

Snake Hill beds. Snake hill, Saratoga county, N. Y.

Saffordia ulrichi nov.

Page 107

Fig. 17, 18 Lateral and anterior views of holotype. Natural size.

Schenectady beds. Schenectady, N. Y.

All originals are in the New York State Museum.

1 2 3 4 5

6 7 8 9 10

11 12 13

15 16 14

17 18

G. S. Barkentin del.

Plate 7

Archinacella orbiculata (Hall)

Page 108

Fig. 1, 2 Very little distorted specimens. x 2. From squeeze.
Snake Hill beds. Snake hill, Saratoga county, N. Y.
Fig. 3, 4, 5, 6 Dorsal and lateral views of Hall's types. x 2.
Snake Hill shale. Near Waterford, N. Y.

Cyclonema montrealense Billings

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Fig. 7 Specimen. x 1.5. From squeeze.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Cyclonema cushingi nov.

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Fig. 8 Surface of holotype. Natural size. From squeeze.
Fig. 9 Cast of interior of same.
Fig. 10 Surface sculpture. x 5.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Pterotheca cf. **canaliculata** (Hall)

Fig. 11 Specimen, somewhat crushed. Natural size.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Hyolithes pinniformis nov.

Page 111

Fig. 12 Holotype, showing a septum near the apex. x 5.
Fig. 13 Paratype. x 5.
Canajoharie shale. Canajoharie, Montgomery county, N. Y.
All originals are in the New York State Museum.

G. S. Barkentin del.

Plate 8

Orthoceras arcuolineatum nov.

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Fig. 1 Holotype. Natural size.
Fig. 2 Section of same.
Canajoharie shales. Fort Edward, Saratoga county, N. Y.

Orthoceras hudsonicum nov.

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Fig. 3 Fragment showing the septa and surface sculpture. Natural size.
Fig. 4, 5 Two specimens showing the protoconch. x 5.
Fig. 6 Section of same, showing the first funnel at *a*. x 5.
Fig. 7 Straight specimen, from the Schenectady beds at the Dettbarn quarry near Schenectady and possibly different. Natural size.
Fig. 8, 9 Specimens that are slightly curved in the apical (neanic) region. Natural size.
Fig. 10 Section of neanic conch showing the closely arranged septa. Natural size.
The holotype (fig. 8) and the originals (paratypes) of figures 4, 5, 6, 9, 10 are from the Canajoharie beds at Alplaus; the original of figure 3 is from Watervliet, and that of figure 7 from the Dettbarn quarry at Schenectady.

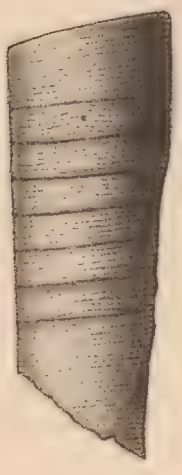
Orthoceras cf. **amplicameratum** (Hall)

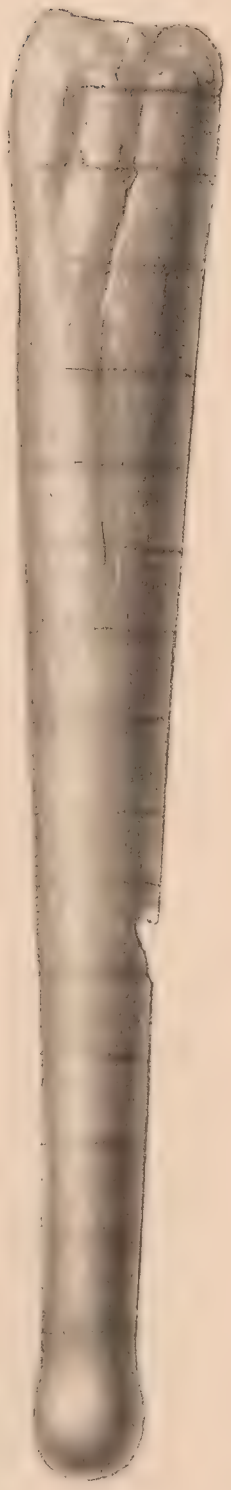
Fig. 11 Fragment, much compressed. Natural size.
Canajoharie shale. Near Glens Falls, N. Y.

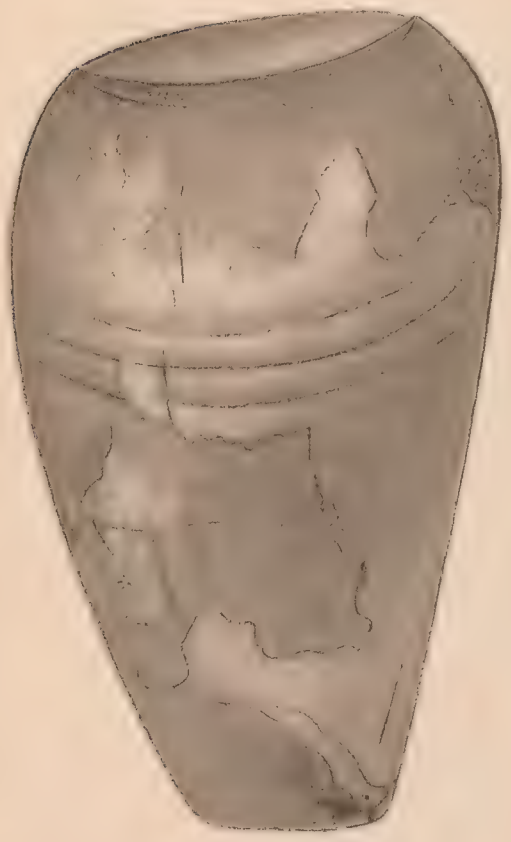
Oncoceras (?) sp.

Page 115

Fig. 12 A completely flattened specimen.
Snake Hill beds. Signal Works near Albany, N. Y.
All originals are in the New York State Museum.







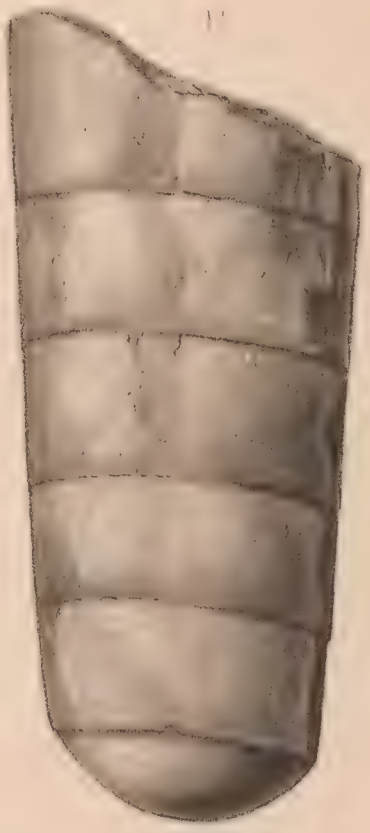


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Plate 9

Eoharpes ottawensis (Billings)

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Fig. 1 Specimen, somewhat laterally compressed. Natural size.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Proëtus undulostriatus (Hall)

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Fig. 2 Hall's type. x 3. From squeeze.
Fig. 3 Cranidium. x 3.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Acidaspis crossota (Locke)

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Fig. 4 Free cheek. x 6.
Fig. 5 Cranidium. x 5.
Indian Ladder beds. Indian Ladder, Albany county, N. Y.

Calymmene senaria Conrad var.

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Fig. 6 Young, fairly complete individual, showing the medial tubercle on the occipital ring. Natural size.
Fig. 7 Protaspis stage. x 20.
Fig. 8 Nepionic stage. x 20.
Fig. 9 Early neanic stage, showing the appearance of the glabellar lobes in the glabellar furrows. x 20.
Fig. 10 Mature individual, much flattened. Natural size.
Canajoharie shale. Canajoharie and Sprakers (figure 10), Montgomery county, N. Y.

Ulrichia ? bivertex Ulrich

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Fig. 11 Right valve, showing normal expression of form. x 20.
Fig. 12 A left valve with slightly different aspect. x 20.
Canajoharie shale. Canajoharie, Montgomery county, N. Y.

Primitiella unicornis Ulrich var.

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Fig. 13, 14 Two right valves showing the elongate form and the lateral node. x 20.
Canajoharie shale. Canajoharie, Montgomery county, N. Y.

Ceratopsis chambersi (Miller) var.

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Fig. 15 Left valve showing the average expression of the variety.
Indian Ladder beds. Indian Ladder, Albany, N. Y.

Eurychilina subradiata Ulrich

Fig. 16 Right valve. x 10.
Glens Falls limestone. Canajoharie, Montgomery county, N. Y.

Technophorus cancellatus Ruedemann

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Fig. 17 Right side of a somewhat imperfect carapace, retaining the surface sculpture. x 4.

Fig. 18 Cast of the interior of the right side retaining the undivided "beak." x 2.

Snake Hill beds. Snake hill, Saratoga county, N. Y.
All originals are in the New York State Museum.

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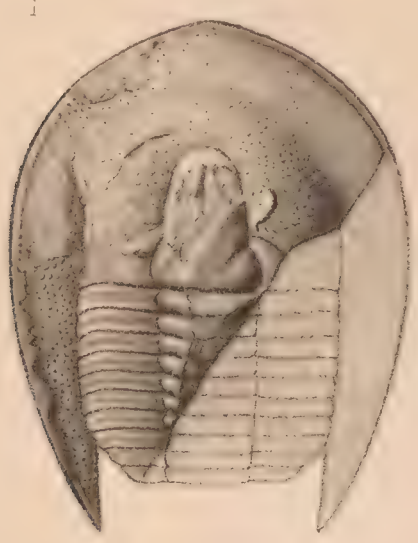

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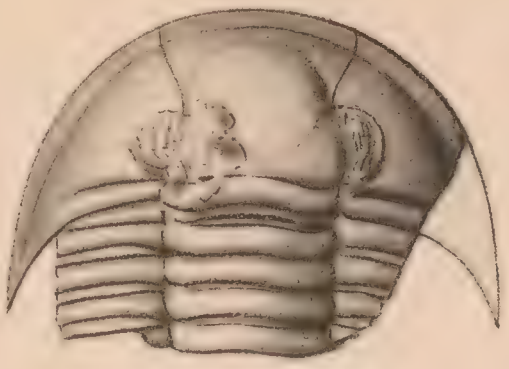

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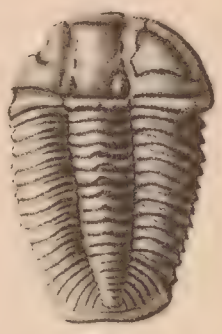

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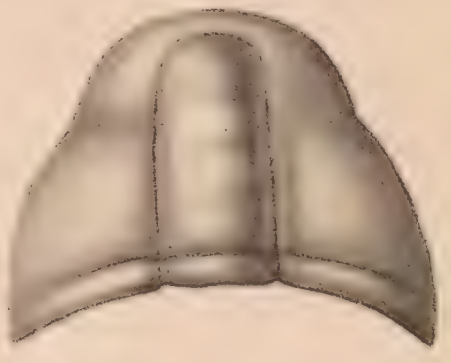

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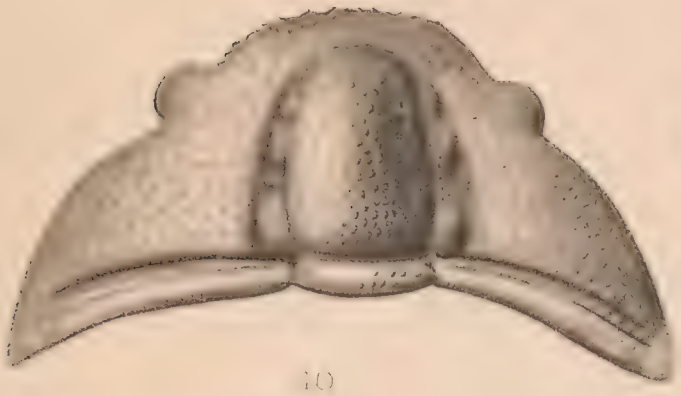

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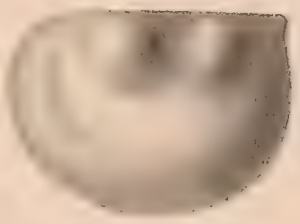

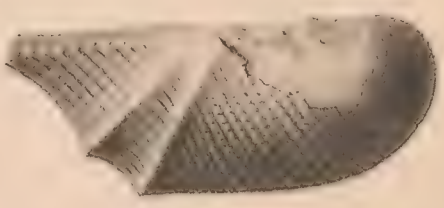

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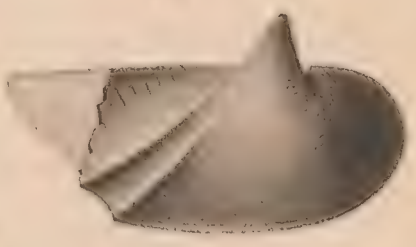

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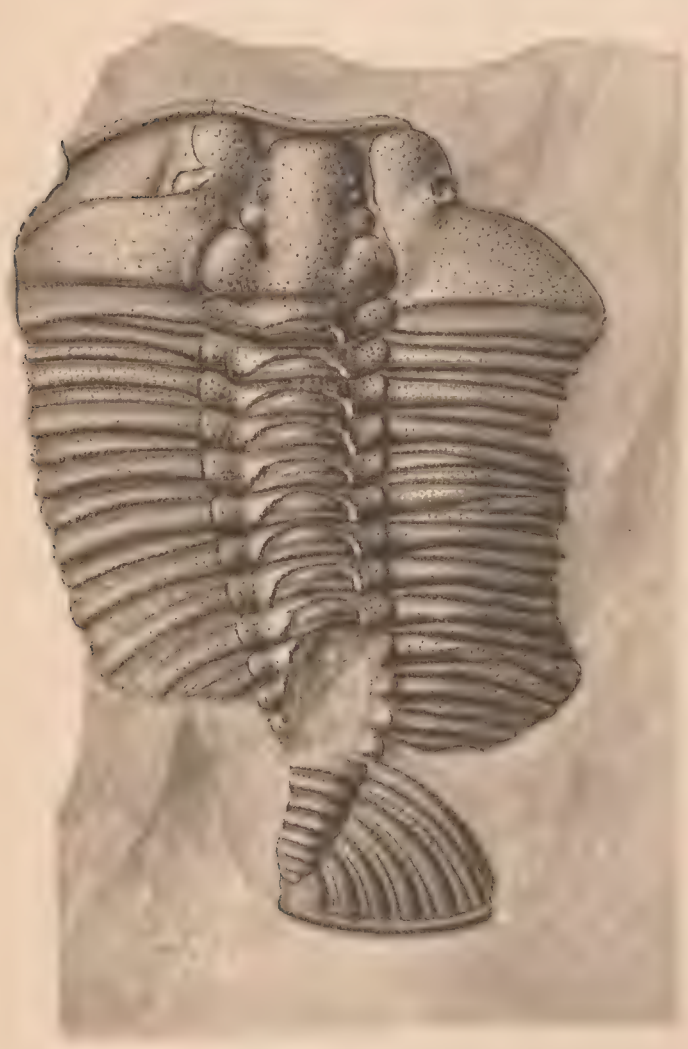

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Plate 10

Isotelus gigas DeKay

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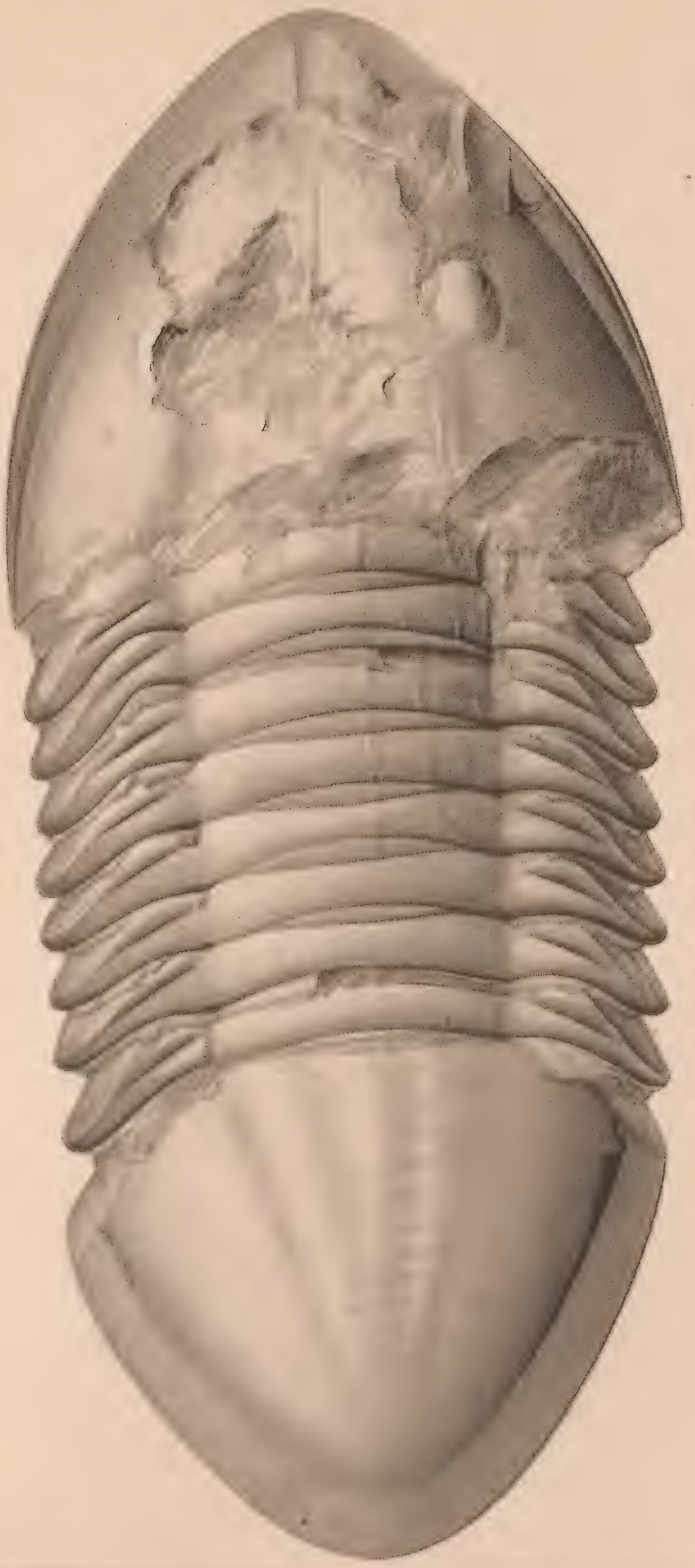
Fig. 1 Specimen somewhat laterally compressed, reproduced in natural size.

Schenectady beds. Rexford Flats, Saratoga county, N. Y. Original in the New York State Museum.



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